HANDBOOK OF STEAM SHOVEL WORK

THE BUCYRUS COMPANY

SOUTH MILWAUKEE, WISCONSIN.

HANDBOOK OF STEAM SHOVEL WORK

CHAPTER I

NATURE OF THE PROBLEM

The steam shovel effected a revolution in the cost of loading earth and other excavated material from the date of its introduction, and it is to-day the standard machine for handling economically such materials in large quantities. It is a highly specialized machine, requiring many accessories in the way of plant for the transportation process. Its efficiency depends upon the skill of its operators, the co-operation of many different men, and the ability with which the general operating scheme of which it is a part, has been designed.

Many a steam shovel has been considered inefficient when it had not half a chance to do its work, and many excavating jobs could have been handled advantageously with steam shovels instead of by hand had the contractors known how to bring them into play. Up to this time no effort has been made, within our knowledge, to put into available shape for ready reference the various quantities and factors which go to make up the cost of steam shovel work, so that it may be determined whether a particular shovel is doing its full duty, and whereby, with careful study of daily performance, a losing contract may be turned into a paying one. To set before the man interested in steam shovel work the necessary data to enable him to work out the economics of his shovel work at the least cost is the problem that we have attempted to solve in this volume. There are so many factors entering into the work that the problem seems at first highly complex; but systematic analysis has resulted in so simplifying it that any man of field experience ought to be able, with the help of the data contained in these pages, to put his shovel work on a scientific basis. To determine what work is costing day by day is half the problem; to determine what it ought to cost is the other half.

To establish these factors it was necessary to observe a large number of shovels in operation, and an elaborate description of the work observed has been necessary in order to afford an adequate statement of the result. These appear in Chapters V to IX inclusive. Wherever possible, the observations have been made by our men. On questions of coal and oil consumption and the like we have had to take the statements of shovel runners, checked more or less by our own observations, and in the items of repair cost, etc., we have had to rely on the statements of others. Where such statements have seemed not to be accurate, we have discarded them.

PROCESS OF LOADING The process of loading consists in seizing the material after it has been reduced to a fit condition and placing it either in its ultimate position or upon a vehicle for the purpose of transportation. With hand shovels, unless the material be sand or gravel or very soft loam, it is essential that it be broken in order that the workmen may be able to handle it. With a steam shovel, however, much of the breaking can be done by the power of the shovel itself aided by teeth which are fastened to the dipper, so that, in many instances, rock which has been imperfectly blasted is further reduced by the crushing and tearing up of the teeth driven by the steam power of the shovel's mechanism. The steam shovel then is frequently called upon to perform not only its proper function of loading, but to a large extent the other process of breaking the material.

THE STEAM SHOVEL VERSUS HAND LOADING

It needs no argument to establish the superiority of machine work over hand labor wherever the amount of work to be done justifies the use of the plant. It is a general rule that, if many foot pounds of work have to

be performed, the horse is more economical than the human engine, and the steam engine far more than the horse. Thus, loading into wagons by teams and scrapers may be done a little more economically than by hand, while the efficiency of a steam shovel above that of a horse team is far more than that of the horse team above that of the man with the hand tool.

COST OF WORK BY HUMAN POWER EXPENSIVE IN PROPORTION TO THE UNITS OF WORK TO BE DONE

The unit cost of loading by hand will be nearly the same, field conditions being equal, whether the job is a large one or comparatively small, the so-called preparatory costs, which will be referred to later, being almost negligible. Thus we know that a man can load by hand into an ordinary wagon, at a cost of from 10 cents to 20 cents per cubic yard, on the basis of 15 cents an hour for wages, the cost varying between these limits according to the condition and weight of the material and the size and kind of shovels and the efficiency of the organization. This performance ought to be feasible whether digging cellars, building a railroad embankment, dam, or any other general type of work, small or large.

GREAT VARIATION IN STEAM SHOVEL EFFICIENCY

In contrast to the above, the steam shovel is dependent for its work upon so many factors, any one of which may very greatly help or hinder it, that there is a far greater diversity of results than in the case of the hand work. Thus, on the standard basis for labor that we have assumed in this report, the direct labor cost alone for loading varies from ½ cent to nearly 13 cents per cubic yard, as observed.

TRAINED LABOR NECESSARY ON STEAM SHOVEL WORK

For the most economical operation it is necessary not only that the shovel runner and craneman be skillful men, but that they shall have been accustomed to work together, and that the other men on the work who are engaged in co-ordinate processes be properly trained to work with the shovel crew; otherwise the work will not run smoothly and the cost will be correspondingly high. Bad co-ordination on such work will inevitably cost more than correspondingly bad co-ordination in hand work.

CO-OPERATION OF OTHER PROCESSES WITH THE STEAM SHOVEL WORK

When a shovel is loading rock, for instance, its own efficiency is very dependent upon the manner and thoroughness with which the rock has been broken. The blasting must be of such quality as to break up the rock so that the shovel can easily handle it without leaving ridges that prevent the laying of the shovel track to grade. We have had experience with work where, because the blasting charge was not concentrated in the bottom of the holes, the ridges were so pronounced that the shovels were unable to operate more than 50 per cent of the working day, the rest of the time being spent in waiting while the rock was "mud capped." Here inefficiency of shovel work was due entirely to improper blasting.

HOW MUCH WORK MUST THERE BE TO ECONOMICALLY JUSTIFY THE USE OF A STEAM SHOVEL?

This question is vital on a large percentage of all excavation contracts. To answer it, simply calculate the total cost, including the cost of installing the plant,

and divide this total by the cubic yards of material to be handled. A comparison of the quotients for the different methods will indicate which one should be followed. A list of the various items that are usually included in a contractor's cost is given in Chapter IV.

Fig. 1. 95-Ton Bucyrus Shovel Digging Ore on the Mesabi Range
See page 236

CHAPTER II

GENERAL CONDITIONS AND FORMULAS

REPAIRS The cost of repairs should be apportioned to the work turned out rather than considered as a function of the age of the shovel. It will be higher for rock than earth work and higher for badly broken rock than for well blasted material. Thus, in a given material, the repair bill for a season's output of 500,000 cubic yards may be expected to be twice that in which the shovel loaded only 250,000 yards. Time alone does not affect the unit cost of repairs. The reverse of this proposition obtains in the case of

DEPRECIATION If the machine be kept in proper repair the depreciation in its value is affected by time alone, regardless of the work that it is doing. Many concerns class the depreciation and repairs under one account, but this practice is inaccurate and misleading. There is great disagreement among accountants as to how depreciation should be figured, and there are many so called depreciation formulas and "curves." The simplest to use, and one which for steam shovel work is satisfactory if proper allowance be made for repairs, is the "right line formula," which is as follows:

$$X = \frac{(a - b)\frac{c}{d}}{a}, \text{ where } a = \text{original value,}$$

$b =$ value on removal or sale,
$c =$ time in use,
$d =$ estimated life,
$X = \%$ of depreciation.

Then X divided by the output for the period c will be the cost of depreciation per unit of performance.

The working life of a steam shovel may safely be assumed at 20 years, and taking the first cost at, say,

\$150 per ton, and its scrap value at \$10 per ton, the value for X, with a ten-year old shovel, would be

$$\frac{(\$150 - \$10)\,\frac{10}{20}}{\$150} = 46.67\% \text{ in the ten years, or } 4\tfrac{2}{3}\% \text{ per}$$

year.

To estimate the depreciation per unit of output it is necessary to distribute this amount over the working time. The method of doing this is indicated in the latter part of this chapter, under typical Standard Steam Shovel Work.

INTEREST The interest on all the money invested in this work must be included as part of its cost. We have assumed this at the uniform rate of 6 per cent.

HEIGHT OF BANK In different classes of steam shovel work, the height of the face to which the shovel can work has an important bearing upon costs. The reason for this is that the higher the bank, the larger the amount that the shovel can load without moving up.

STANDARD RATES It is of no interest to contractor Jones how much contractor Smith paid his men, or for his coal a year or two ago, and Smith usually dislikes to have these exact rates published, on account of possible trouble within his own organization; but it is of importance to be able to compare the efficiencies of different methods in different places, so that any contractor using this volume may be able to estimate the value of any special methods herein described. Such comparison is valuable for making estimates on future work, and it is greatly

facilitated by giving the data observed in terms of an assumed standard rate of pay for each class of men and materials. We have therefore given our cost data in these "standard" figures.

FORMULAS AND DIAGRAMS

TYPICAL STANDARD STEAM SHOVEL WORK

MATHEMATICAL ANALYSIS AND CURVES OF COST

The following analysis of steam shovel work and the accompanying curves of cost are useful in enabling a rapid estimate to be made of the approximate cost of steam shovel work in progress or proposed.

d = time in minutes to load 1 cubic foot with dipper (place measure).
c = capacity of one car in cubic feet (place measure).
f = time shovel is interrupted while spotting one car.
e = time shovel is interrupted to change trains.
g = time to move shovel.
L = distance of one move of shovel.
N = number of shovel moves.
M = minutes per working day less time for accidental delays.
A or B = area of shovel section excavated in square feet.
R = cost per cubic yard on cars in cents, for shovel work only (place measure).
L A N = cubic feet excavated per day.
C = shovel expense in cents, one day, not including superintendence and overhead charges and not including preparatory charges.
n = number of cars in train.

(1) Time to load one car = d c.

(2) Time to load one train = n d c + n f + e.

(3) Number of trains for one shovel move $= \frac{L\,A}{n\,c}$.

(4) Time between beginning of one shovel move and beginning of next

$$(ndc + nf + e)\,\frac{L\,A}{n\,c} + g.$$

(5) $$N = \frac{M}{\left(dc + f + \frac{e}{n}\right)\frac{L\ A}{c} + g.}$$

(6) $$R = \frac{27\ Cd}{M} + \frac{27\ C}{M}\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$$

This is the equivalent of the equation $R = md + b$.

(7) Where $m = \frac{27\ C}{M}$, and

(8) $$b = m\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$$

We have assumed for the typical example a shovel valued at, say, $14,000, and the following daily expense:

	Per Year
Depreciation, 4⅔%	$653.34
Interest, 6%	840.00
Repairs, when working one shift	2000.00
	$3493.34

Per year of 150* working days, or $23.29 per working day,	$23.29
Shovel runner	5.00
Craneman	3.60
Fireman	2.40
One-half watchman at $50 per month	1.00
6 pitmen at $1.50	9.00
1 team hauling coal, water, etc., half day, say, at $5	2.50
2½ tons coal, at $3.50	8.75
Oil, waste, etc., say	1.50
	$57.04

It appears that the equation: $R = md + b$, is that of a straight line. Now since in this equation $m = \frac{27\ C}{M}$ and $b = m\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$ all quantities involved in the equation excepting d are, or are assumed to be, constant. The data upon the value of these quantities furnished by the accompanying

*For various reasons, such as weather, lack of continuous work, transportation of plant, etc., we have assumed the average working year as composed of 150 working days. This, of course, will be greatly affected by local conditions.

reports have been presented in graphic form with all influencing factors noted on the five plates, A, B, C, D and E, bearing the heading *for use with cost curves.* See pages 20 to 24 inclusive.

Plate A indicates the time to load one cubic yard, place measure, in various kinds of material. Plate B deals with the quantities e, average time shovel is interrupted to change trains. For use in plotting the equation above, those average values of e, n, c and f, involved in ordinary contracting work where side dump cars are used, have been tabulated separately on plate C. It will there be seen that the average value for e, the time between trains, is 4 minutes. The average number of cars per train, or $n = 10$. The commonest form of contractors' side dump car is of 4 yards water measure, or 2.5 yards place measure capacity*, and we therefore take $c = 67.5$ cubic feet. The ordinary value of f is zero, since the cars are almost invariably spotted while the shovel is swinging and digging. Plate D deals with the values of M or the working time, including actual shovel time, waiting for trains, and moving up, but not accidental delays. Plate E deals with the time of moving up, an average value for which is 8 minutes.

The constants having been thus established, three sets of curves have been plotted on the plates headed *cost curves*, I, II and III, one for each of the three values of L A 1500, 3000 and 6000 cubic feet (L being the average shovel move, 6′, and A the area of the dug section in square feet). Each of these sets of curves has been plotted for values of M, ranging from two hours to ten hours by hourly intervals, between which intervals our observed values (see plate C) fall.

We have found it much more convenient to make use of our data when arranged in this manner, both for field work and for the purposes of the estimator,

*This is a general average. It varies a good deal with the character of the material handled.

than when expressed in long tabulations. Moreover, when cost data are presented in the detailed form contained in this volume they are applicable to a far wider range of new conditions than when simply given in totals as records of cost. Attempts have been made to discredit cost data on the ground that they are of no use to anyone except him who did the work or made the original observations, or on the ground that to a reader who has perhaps never seen the job at all there will be so many unknown conditions, that when applying the data to his own work he cannot be sure of having conditions sufficiently similar to make comparisons safe. Moreover, skill in management varies greatly with different organizations, and a reader may not have the same ability in organizing or handling work as some of the people whose performance has been herein described. This is very true, and if the reader can do as well as any one of several of the managers whom we met in getting up these data, he may be proud, as well as wealthy; but cost data on any work, if presented in sufficient detail and with clearness, will be useful to any man, good, bad, or indifferent, who will intelligently study them. If he attempt to proceed with improper study of the data or of the work that he is trying to do himself, he will fail just as he would without the data, which in all cases must be taken with intelligent discrimination.

In the formula for steam shovel loading cost are some ten quantities that vary on different pieces of work. Some of these are dependent on the kind of material and equipment, some depend on the efficiency of the management alone, and some few are affected by conditions beyond control or foresight, such as weather. The first two can be "standardized" and the other must be estimated by us for purposes of illustration and by the reader for his own use. Even in the case of weather, there is not as much uncertainty as

would at first appear, for over a long working season the number of days suitable for operating may be pretty well estimated in most climates by going over the Weather Bureau records for the neighborhood.

Because the meaning and general bearing of a mass of data can be grasped by looking at charts much more readily than by any other method known to us, we have used them in this volume.

STANDARD ASSUMPTIONS These have been made to facilitate the chart work, and because from our experience they are entirely justified in practice. When, for example, we assume that the time to move a shovel is four minutes, though some men take fifteen, and a few two or three, we are justified by a vast number of cases in which the moving was actually done in four minutes. If the reader find that his men are taking eight or ten minutes, an application of the rules given in Chapter X, will save him some money. The assumptions for "A" depend upon the field conditions, and the reader must use the particular plate that most nearly represents the section area of his job, or else must make up his own chart, not a difficult or laborious operation in any event.

USES OF COST CURVES

There are two important uses to which these curves of cost can conveniently be put.

1. Estimating the cost of proposed work.
2. Checking up the cost of work under way.

In estimating we may proceed as follows:

Assuming that the proposed work is to be a railroad cut in rock, with average equipment, there are then only three quantities to decide upon, namely, L A, 27d and M. The area of the shovel section being assumed at 250 square feet and the average distance

of move being 6 feet, L A will equal 1500 cubic feet. Now refer to plate A and select a fair value for the time of loading one cubic yard in rock work. Suppose 30 seconds be chosen. Next refer to plate D for the proper value of M to use for rock work. The average value is 8 hours (80 per cent. of 10 hours). The cost per yard in cents can now be read directly on cost curves, plate 1. With abscissa (27d) as 30 seconds glance upward till the vertical line through 30 seconds intersects the 8 hour, M line. Then on the left opposite this point of intersection read 9½ cents as the cost per cubic yard loaded, place measure.

It may be noted here that with respect to the two important items of time to load 1 cubic yard with dipper and values of M, the cost curves are perfectly flexible. Variation in the value of the constants may be allowed for by proper choice of M. In connection with the formula it is interesting to note the effect of decreasing the carrying capacity of each train, other conditions remaining the same. Suppose the carrying capacity to be decreased from the average, 10 x 2.5 yards = 25 cubic yards to 8 x 2 yards = 16 cubic yards, place measure, what would be the effect upon the cost per cubic yard? The new cost per cubic yard, place measure, would be 10.6 cents against the former 9.5 cents, an increase of 1.1 cent per yard, or 10 per cent.

To use the curves for checking the cost of work in progress proceed as follows: The field operations are few and simple. Find the average time per dipper swing. Knowing the rated capacity of the dipper and the character of the material, a glance at the tabulation near the top of plate A will give the ratio of dipper capacity, place measure, to dipper capacity, water measure, and by using this factor the average capacity of dipper, place measure, can be obtained, and thence the time to load 1 cubic foot or yard. Suppose for instance the average

time per swing to be 25 seconds, material earth, and capacity of dipper $2\frac{1}{4}$ yards. On plate A, under heading "Ratio of $\frac{\text{place measure}}{\text{water measure}}$" we find for earth the average value for $\frac{\text{place measure}}{\text{water measure}}$ given as 0.53. Therefore $2\frac{1}{4} \times 0.53 = 1.2$ yards per swing or 2.88 yards per minute, or .35 minute per cubic yard. Make some rough measurements to determine the approximate area of the shovel section and multiply this area by the length of move up and get L A, say 3000. Then, from previous observations or by an estimate of M, get the time worked per day, less accidental delays, say 9 hours. Now take cost curves, page 26, and with .21 as abscissa read opposite the line for M = 9 hours, 6 cents as the cost per yard place measure. If the constants in the formula do not agree closely enough with actual conditions, allow for this by choosing a suitable value of M. or substitute directly in the equation for cost.

Note that the above costs do not include superintendence or overhead charges, and cover only the cost of loading. Transportation, dumping, spreading and preparatory costs are not included.

These plotted charts have been given to assist the man who is accustomed to charts to use the observed data contained in this volume. By their use it is much easier to pick out the conditions that fit any particular piece of work, or a particular example to fit the conditions of the work to be done, and thus make the data available with less time than would be necessary if all the figures were given in tables.

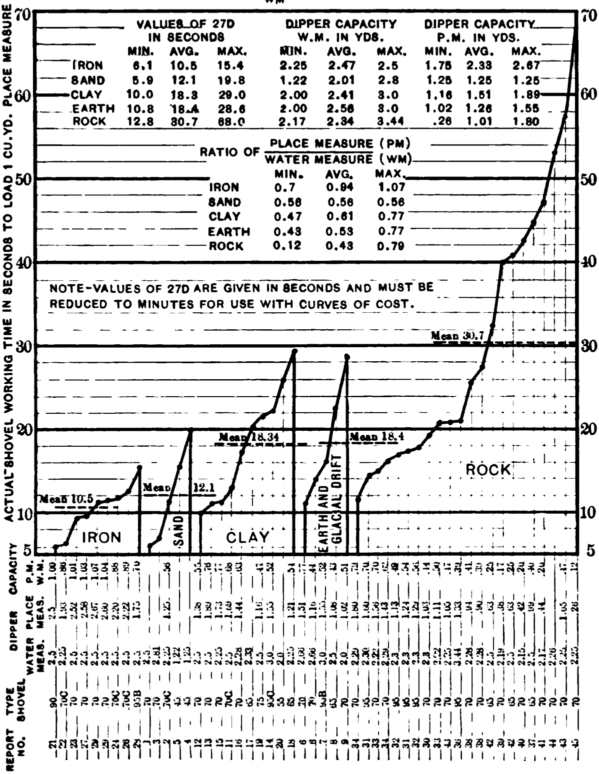
It should be particularly noted that for plotting the two co-ordinates certain assumptions are necessary because there are a large number of variables in the theoretical steam shovel formula. Thus, we have made three plates—one where the expression L A is 1500

cubic feet, one where it is 3000, and one where it is 6000. We have also made an assumption of $57.04 for the value of C. Where the shovel differs very much in type from the one mentioned or where the rates of labor are very different from those assumed, it will be necessary to compensate for the difference between the new value of C and the one that we have used in the diagrams. The easiest way to do this is to multiply the figures taken from the diagrams by the ratio between the new value of C and the assumed one. Thus, if the shovel costs per day turned out to be $65 instead of $57.04, and the diagram should give a cost per cubic yard for loading of 12 cents, we would have for our charge 12 cents multiplied by $65 and divided by $57.04, or 13.67 cents per yard. As heretofore indicated, this does not include the cost of overhead charges, superintendence, and preparatory charges, which in all cases must be added for purposes of estimating. It will be well worth while for the man who contemplates doing shovel work to give these diagrams and the formulas most careful study, and to make up for his own work, substituting in the formula the constants that he expects to obtain, diagrams that will be exactly suited to his particular case.

FOR USE WITH COST CURVES PLATE "A"

VALUES OF 27D SHOWN GRAPHICALLY BY BROKEN LINES BELOW.

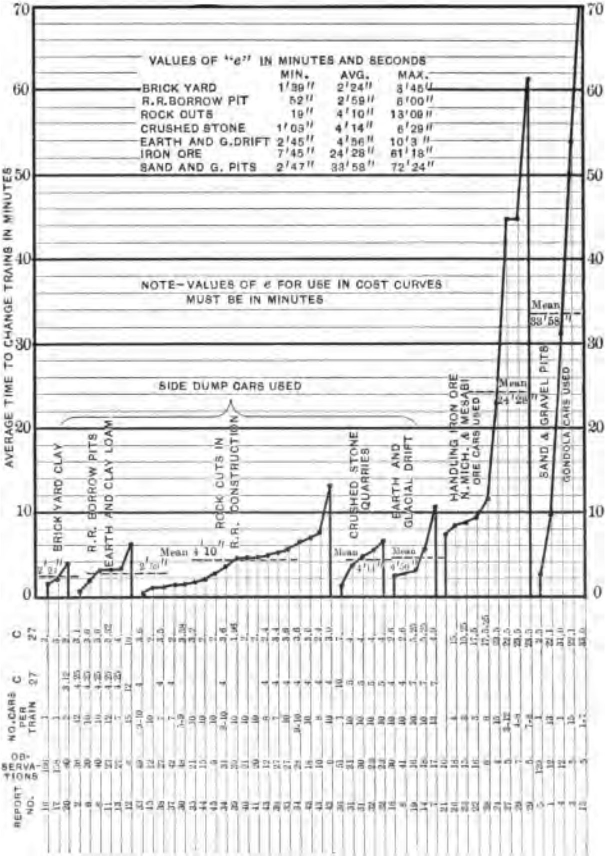
FOR VARIOUS RATIOS OF $\frac{PM}{WM}$, IN DIFFERENT KINDS OF MATERIAL



FOR USE WITH COST CURVES PLATE "B"

VALUES OF "e" SHOWN GRAPHICALLY

AVERAGE TIME TO CHANGE TRAINS



FOR USE WITH COST CURVES PLATE "C"

Values of e, n, c, f, involved in ordinary contracting work with side dump cars.

e = Average time shovel is interrupted to change trains.
n = Number of cars per train.
c = Capacity of cars in cubic feet (place measure).
f = Time to spot one car.
c' = Capacity of cars in cubic feet (water measure).

	Values of n			Values of c			f	c'
	Min.	Avg.	Max.	Min.	Avg.	Max.		
Brick yard clay .	1	1-2	2	54	72	81	Zero	. .
R. R. borrow pits	7	11	15	83.7	126	270		151
Rock cuts . . .	7	9	12	54	75	97.2		188
Crushed stone quarries . .	1	10	10	108	124	189		162
Earth and glacial drift	10	10-11	13	70	108	141		157
Iron ore . . .	3	7	12	270	540	675		540
Sand and gravel pit	1	7	15	67.5	598	891		. .

General average of e, n, c, f, c', as follows

	No. of Obs.	Minimum	Average	Maximum
e	35	.25 min.	4.00 min.	13.5 min.
n	35	5.0 cars	10.00 cars	15.0 cars
f	0	0	0	0
c	35	2 yards	4.00 yards	10.00 yards
c'	27	4 yards	5.00 yards	12.00 yards
c/c'	27	0.5	0 8	0.95

FOR USE WITH COST CURVES PLATE "D"

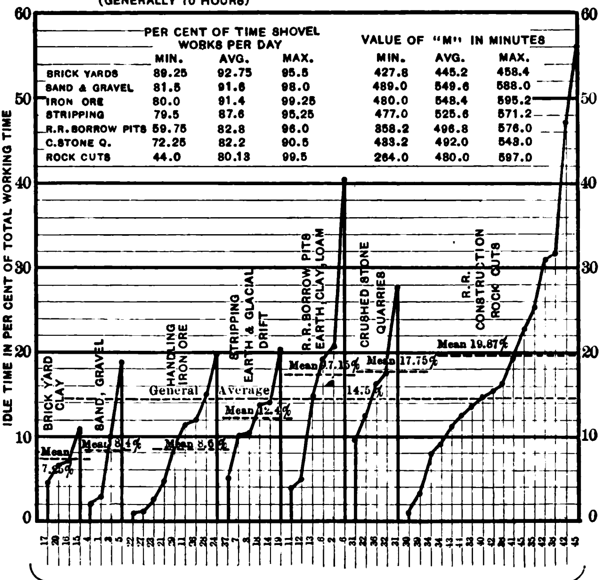
AMOUNT OF IDLE TIME SHOWN GRAPHICALLY IN PER CENT OF TOTAL TIME WORKED EACH DAY

VALUES OF "M" TO BE TAKEN FROM THIS TABLE

"M" = ACTUAL WORKING TIME OF SHOVEL

TO FIND "M" TAKE VALUE PLOTTED BELOW, SUBTRACT FROM 100% AND MULTIPLY RESULT BY TOTAL WORKING TIME PER DAY. (GENERALLY 10 HOURS)

	PER CENT OF TIME SHOVEL WORKS PER DAY			VALUE OF "M" IN MINUTES		
	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.
BRICK YARDS	89.25	92.75	95.5	427.8	445.2	458.4
SAND & GRAVEL	81.5	91.6	98.0	489.0	549.6	588.0
IRON ORE	80.0	91.4	99.25	480.0	548.4	595.2
STRIPPING	79.5	87.6	95.25	477.0	525.6	571.2
R.R. BORROW PITS	59.75	82.8	96.0	858.2	496.8	576.0
C. STONE Q.	72.25	82.2	90.5	483.2	492.0	548.0
ROCK CUTS	44.0	80.13	99.5	264.0	480.0	597.0



Report No. 15 Worked in Slag

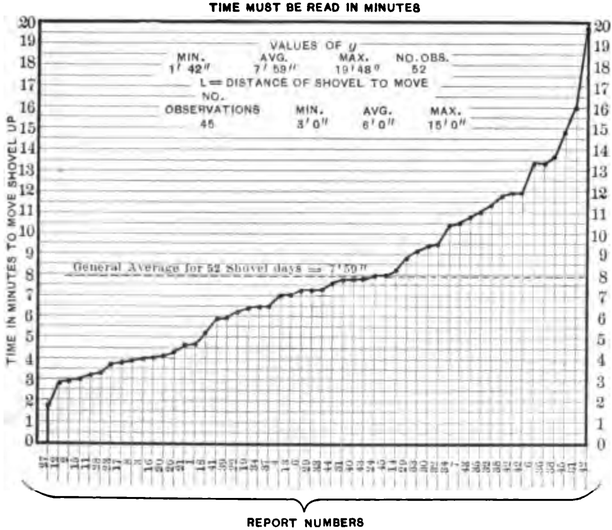
Report No. 43 Rock Cut on Soo Canal Widening

FOR USE WITH COST CURVES PLATE "E"

VALUES OF "g" SHOWN GRAPHICALLY AS TAKEN FROM THE VARIOUS REPORTS

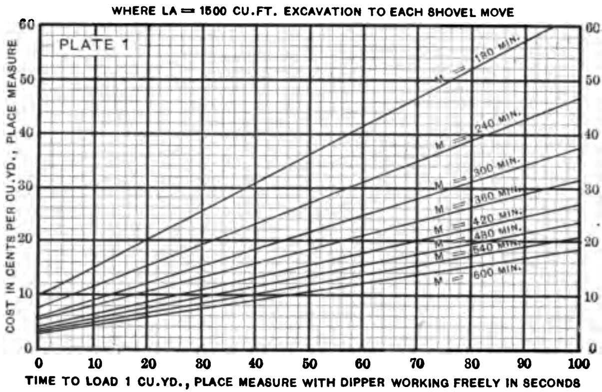
g = TIME TO MOVE SHOVEL UP

TIME MUST BE READ IN MINUTES



NOTE—Shovel on Report No. 9, Engaged in Sewer Excavation, Averaged 33' 45" to Move Up. It was Moved on Wooden Rolls

COST CURVES



FORMULA

$$R = \frac{27Cd}{M} + \frac{27C}{M}\left(\frac{f}{c} + \frac{e}{nc} + \frac{g}{LA}\right)$$

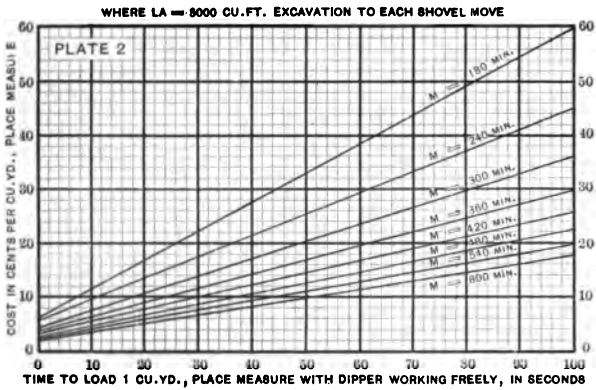
Assume:

- f = 0, interruption of shovel while spotting cars.
- e = 4 minutes of time between trains.
- n = 10, number of cars per train.
- c = 2.5 yards place measure = 67.5 cubic feet.
- C = 5704 cents, daily cost.
- M = Actual working time of shovel.
- g = 8 minutes, see Plate D.
- d = Minutes to load 1 cubic foot, place measure.

COST CURVES

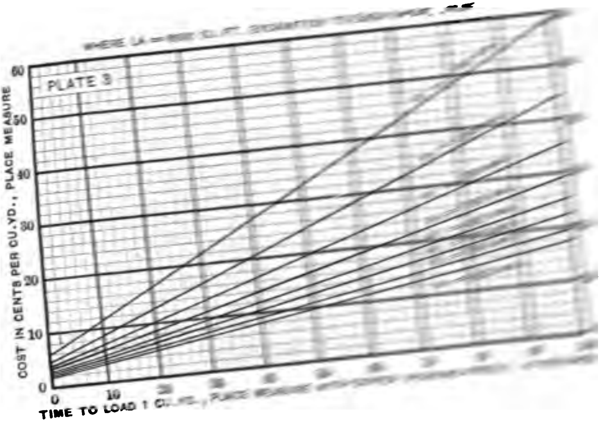
DAILY COST "C" AS FOLLOWS

Plant depreciation on shovel valued at $14,000, say, 4⅔ per cent	$653.34
Interest, 6 per cent.	840.00
Repairs	2000.00
	$3493.34



	Per Day
$3493.34 ÷ 150 days equals	$23.29
Shovel runner	5.00
Craneman	3.60
Fireman	2.40
½ watchman	1.00
6 pitmen, at $1.50	9.00
Teaming one-half day	2.50
2½ tons coal	8.75
Oil, waste, etc.	1.50
	$57.04

COST CURVES



Values of f
Values of e
Values of n
Values of c , Same as used in Plate
Values of C
Values of M
Values of g
Values of d

COST CURVES

DAILY COST "C" AS FOLLOWS

Plant depreciation on shovel valued at $14,000, say, 4⅔ per cent	$653.34
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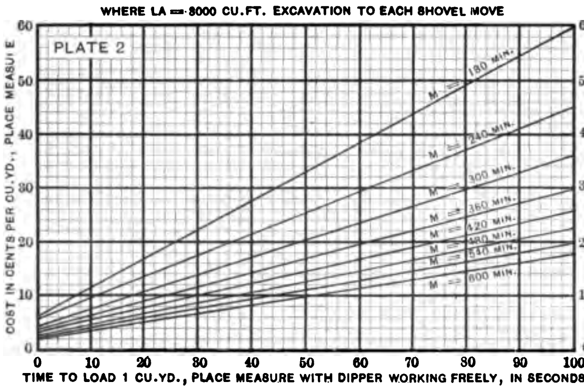

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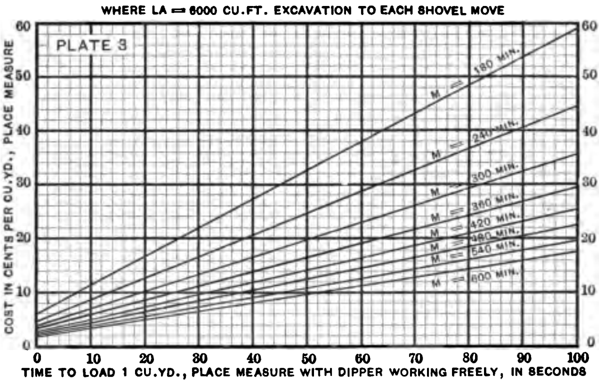
	$57.04

COST CURVES



Values of f
Values of e
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Values of C
Values of M
Values of g
Values of d

} Same as used on Plates 1 and 2.

CHAPTER III

FIELD CONDITIONS

EQUIPMENT To do work economically in the field, it is an axiom that the equipment must be proper in condition and suitable in design. It need not necessarily be of the very latest model, with all the new improvements, for it sometimes happens that the high cost of new equipment may render its purchase inexpedient. But, and this point must receive emphasis, the equipment must be of the right kind and in the right condition. Sand is dug with a large dipper and a sand lip, and rock with a smaller dipper and the best of teeth. We had occasion to reorganize a job on which were working a Bucyrus Shovel of a certain size and one of another make that weighed a good many tons more than the Bucyrus. The work was in rock, badly blasted, and taxed both shovels to the utmost. It happened that because of greater power in the lifting and crowding motions the Bucyrus, which was by far the lighter shovel, was able to do more efficient work in the rock, while there was no appreciable difference in performance in clay and loam, for which materials the other shovel was amply strong. It was entirely capable of carrying a dipperful of rock to the car, but it often stopped when attempting to break rock with the teeth. Experience with another shovel in narrow trenches, demonstrated that it was effecting no saving over hand labor. For digging cellars, or trenches of twice the width of those that it had to excavate, or for clay material free from boulders, it would have been highly economical.

For each piece of work there is economically one best type (not necessarily one best manufacturer) of equipment, and to handle the job cheaply it is necessary to have that type.

SUPERINTENDENCE

The quality and amount of the superintendence will greatly affect the unit costs on the work; and by superintendence we mean not only the man in charge, but his whole directing organization. The work in the iron ore country is an example of what may be accomplished in the way of skilled organization. It is with increasing force coming to the attention of managers that superintendence is a many sided art, requiring study as well as experience, and trained helpers in addition to a timekeeper. Special appliances, such as a stop-watch, record blanks and tally machines, are also necessary for the best of control over the daily conditions. Cost keeping on the job must be applied immediately after performance, or else it is too late to take advantage of the lessons of cost and to economize the work.

Pure observation alone without actual timing, will not show a superintendent whether it is more economical for him to use nine-car or ten-car trains to haul material away from his shovel. Logic alone will tell him whether the shorter or the longer train is the better to use. He will generally favor the use of long ones if his engines will haul them. Yet money has been saved by shortening trains even when the engines could easily haul the longer ones. In this case the key to the situation was the time required to dump and transport.

So many conditions of management enter into efficient steam shovel work, that it is most sensitive to variations in the superintending organization.

GENERAL ARRANGEMENT

This feature always receives great attention from skillful managers. The "old line" contractor comes upon the job and looks it over from the seat of his buggy, deciding on the ground where he will begin operations and how he will remove the material from the

shovels. The modern manager undertakes it much in the manner of a German professor attacking a mathematical proposition. Sometimes there is only one place to "cut in" and only one way to handle the earth or rock; but generally there are several places to cut in and many, many ways available for handling the material. If there were only three ways, and there are seldom less than twenty-three, he is a bold man who would decide off hand which is unquestionably the best of the three, until an economic study has conclusively established the facts. To do this it is necessary to consider methods in use in other places and often in other lines of work. It happened that the subaqueous drill operators developed the fact that pumping a jet of water under high pressure into a drill hole would greatly decrease the cost of drilling rock; and they were led to try the plan because water was just over the side and good force pumps were on board the drill boats. This device in the subaqueous field has saved large amounts of money when applied to drilling on land.

LOST TIME Steam shovel operation is rarely a continuous performance, so far as concerns the shovel itself. There are always delays, some of which are due to breakages on the shovel itself and some to interruptions of one of the collateral processes, breaking or transportation. The most costly of these, in our experience, has been where the shovel was loading blasted rock, and because of imperfect breaking the shovel had to stop from time to time to allow drilling and blasting under the dipper. In one case the interruptions from this cause amounted to nearly 50 per cent, which in an eight-hour day allowed the shovel only four hours for actual work. Under such conditions the transportation facilities must be adequate to keep the shovel working full time, so that delays to the shovel increase the cost of transportation correspondingly.

Accidents to the transportation department, due to bad condition of the equipment, rolling stock, or track, cost just as much as delays of the same duration caused by shovel break-downs. Reserve equipment will often save money in such a situation, but the best safeguard is to give to one man the facilities and responsibility for seeing that all equipment be kept in first class repair. It is customary for shovel crews to make their repairs to the shovel out of working hours and on Sundays whenever possible. On heavy rock work, where many repairs are needed, the crews often have to work nearly every Sunday for an entire season, and the consequent lack of rest and recreation is likely to tell on the men's working efficiency.

Stopping to "chain out" boulders on heavy rock work in shale or the schist of Manhattan Island is likely to account for a lost time bill of 20 per cent or more, and presents a most aggravating and discouraging obstacle to good work. In such cases several extra chains should be provided, and two or three men constantly employed in putting them on the boulders as fast as possible while the shovel is working. Even if these men are often idle for several minutes at a time, the result, in shovel output, of their services is worth more than their pay. After estimating how many cents each dipper swing is worth in pay yardage, it is a simple matter to calculate how much should be spent in keeping the dipper working. Mud-capping the boulders, to save "chaining out," is desirable if it can be done without too much delay. Usually it will be found cheaper in the end to keep a man or two drilling block holes, especially if the facilities permit the use of a small power drill. When thus drilled the boulders can be cracked with small charges and with almost no interruption to the shovel work. With the small drill (like a riveting gun) the holes may be put in on the side of the boulder away from the shovel, if that side can be reached, drilling about

6 to 10 inches deep, tamping with blue clay forced in with the thumbs and fired with a fuse. Very small charges of a rather high powder (50 or 60 per cent) should be used.

A list of the various causes of delay should be kept by the shovel runner, and reported daily, with the duration of each, so that the relative importance of the different causes may be known, and a standard remedy adopted. Whenever such a remedy is needed, the shovel runner can call for it by a whistle signal. The following is a convenient code for these signals, a long toot being indicated by a dash, a short one by a dot:

—	Pit crew get ready to move shovel.
— ·	Get ready to mud cap.
— · ·	Get ready to block hole.
— · · —	We need coal.
· — ·	We need water.
· ·	Waiting for cars (useful to help in spotting cars when dinkey man cannot see hand signals).
·	Stop.
— — —	All ready to blast.
· · · ·	Fire.
· · — · ·	Cars off the track.
· · ·	Back up.
— — · ·	Shovel has broken down.
· — —	Superintendent's call.

A code of these signals in the shovel cab, and one in the hands of each foreman, will be sure to save money by the elimination of the preventable delays.

KIND OF LABOR Running a shovel is a highly trained and a highly paid specialty, and as a general thing shovel runners are intelligent and conscientious, but a good deal depends on the way in which a runner and his craneman work together. If they should be of incompatible dispositions it is often better to move one of them to some other shovel than to have

them work badly together. They must have considerable confidence in each other in order for the attainment of the highest efficiency.

We cannot too strongly emphasize the importance of selecting the most skillful shovel runners and cranemen. The loss of money caused by indifferent ability in these positions may easily be several times as much as the wages of the men themselves.

We have elsewhere shown the economic effect of efficiency in moving the shovel. For this reason the pit crew should be made up of picked men, one of them getting a little more pay than the others perhaps and having authority over them. Thorough organization here may be worth half of the wages of the pit crew. Of great importance in many classes of work is the dump gang, which usually receives but scant attention. In sandy material there should be no difficulty in dumping the cars with great regularity and returning them to the shovel on time, but with clay mixed with boulders a good dump foreman and a lively gang are necessary for good work. The men must realize that they are part of a large machine and that their own delays will impede their fellow workmen. For this reason it is often well to alternate the foreman and some of the men between the different positions. A foreman on the dump will better realize what is expected of him after he has had experience in the pit and on the track laying. Some of the more intelligent men will also be benefited in like manner, while others of less intelligence will not.

KIND AND CONDITION OF MATERIAL The kind of material greatly affects the shovel output, as will be seen from the reports which follow. Rock work will generally cost much more to load than earth, and rock that is badly broken may cost three times as much to load as properly blasted rock. In this case, its condition,

which affects the cost, may be due to the degree of skill used in the preceding process. Clay will vary much in consistency and in the ease with which it can be handled. The higher the face to which the shovel can work, the greater the efficiency, as indicated elsewhere, if other conditions be equal. The safe height of bank, however, is limited by the condition of the material, heavy slides being dangerous. Some banks are too high to be economically workable on account of slides.

Fig. 2. Shovel No. 1108 Cutting-in on D., L. & W. Cut-off. See page 255

CHAPTER IV

ESTIMATING

For purposes of estimating, in order not to forget anything and to facilitate a logical arrangement of the various costs that occur on the work, it is important to have some standard classification of expenses. The ordinary costs are included in the following list, which is used by the Construction Service Company as a standard guide, and which will be found useful as a guide to properly subdivide the cost keeping in the field, and as an aid to the bookkeeper. By using the symbols opposite each name they can be readily and easily referred to. We have found that the mnemonic method is much easier to remember and more satisfactory in operation than a numerical system. It has been in use for some time and it is proving very satisfactory.

STANDARD CLASSIFICATION OF EXPENSES

Classification I. Main Classification of Expenses.

O	Office	Overhead.
X	Miscellaneous	
F	Field	Direct.
U	Sub-contract	

Classification II. Distribution of Classification I.

- L Labor directly productive.
- Lh Hourly labor.
- Lw Weekly labor.
- Lm Monthly labor.
- Li Incidental labor.
- F Labor superintending.
- M Material.
- S Supplies.
- X Miscellaneous.

Classification III. Distribution of Classification II.

R	Repairs	Maintenance.
D	Depreciation	
I	Interest	
S	Storage	

H	Hire or rent	Incidental.
T	Transportation	
O	Organization or preparatory	
X	Miscellaneous	
C	Charity or accidents	
B	Bonus or discounts	
Z	Legal and medical	
P	Publicity or advertising	
A	Accident insurance	
F	Fire insurance	
Q	Theft insurance	
G	Bond to guarantee contract	

Classification IV. Application of Classifications II and III.

E Equipment or plant.
T Tools.
B Buildings.
C Cash capital.
X Miscellaneous.

Classification V. Field Processes.

B Breaking (loosening).
C Construction.
D Dumping.
G Grubbing.
L Loading.
M Mixing.
P Protection.
R Ramming and rolling.
S Spreading.
T Transportation.
X Miscellaneous.

Classification VI. Type of Work.

C Concrete masonry .
E Earth.
L Liquids.
M Brick and mortar.
R Rock.
W Woodwork.

We also give in this chapter some charts made up from our observations, which will be useful in helping to estimate the costs on steam shovel work. Rates of wages must be ascertained for the particular locality in which the work is to be done, and with reference to the

condition of the labor market. It may be noted that certain report numbers are quoted in those charts, the corresponding reports not being found elsewhere in this volume. In such cases the information is on file, but is not published in detail, owing to objection on the part of the company or individual operating the shovels.

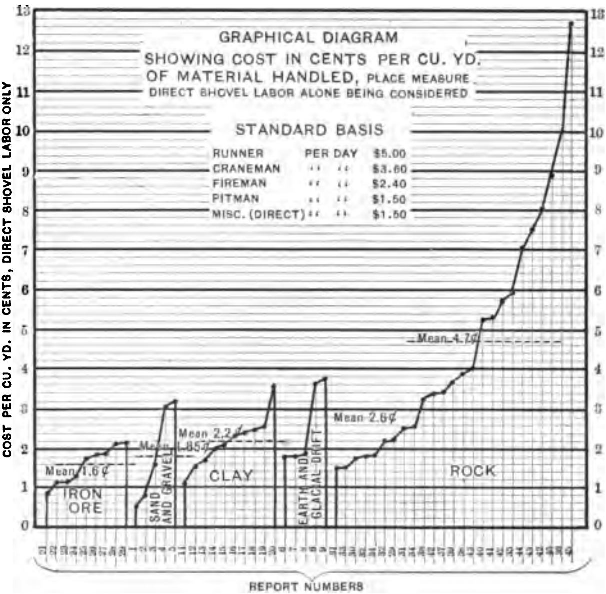
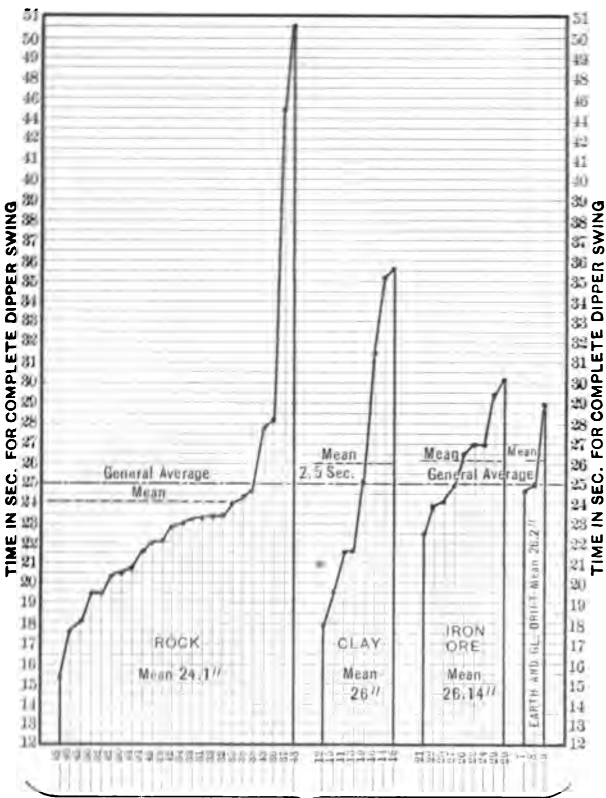
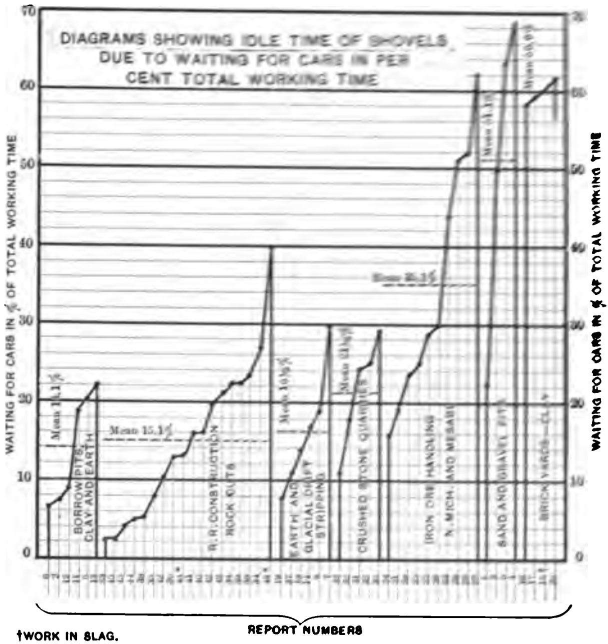


TABLE OF RATES OF WAGES. DIRECT LABOR BUCYRUS SHOVELS

Occupation	No. Obs.	Minimum	Average	Maximum
Runner	41	$75.00 per mo.	$135.00 per mo.	$175.00 per mo.
Craneman	41	55.00 per mo.	96.00 per mo.	125.00 per mo.
Fireman	38	50.00 per mo.	62.00 per mo.	87.00 per mo.
Coalman	8	1.40 per day	1.47 per day	1.50 per day
Pitman	39	1.40 per day	1.90 per day	3.50 per day

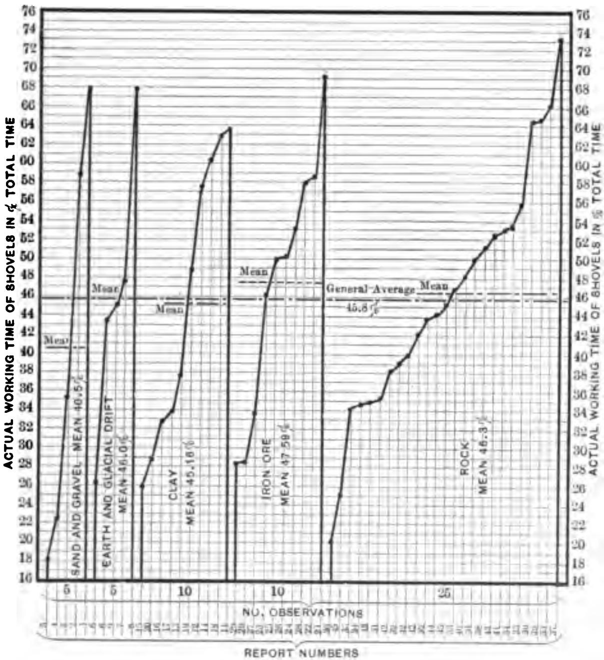


Diagrams of Time in Seconds for Complete Dipper Swing



†WORK IN SLAG.
*ROCK CUT FOR CANAL WIDENING.

DIAGRAMS SHOWING ACTUAL SHOVEL WORKING TIME
IN PER CENT OF TOTAL TIME



Material	Min.	Avg.	Max.	No. Obs.
Sand and Gravel	18.2	40.5	67.6	5
Earth and Drift	26.5	46.0	67.8	5
Clay	26.0	45.16	63.4	10
Iron Ore	28.4	47.59	69.3	10
Rock	20.4	46.3	73.3	25

CHAPTER V

STEAM SHOVEL WORK IN SAND AND GRAVEL

Most of this work is likely to be in a borrow pit, where a large area is to be excavated, and where the installation is of a semi-permanent nature. Many of the banks are very high, requiring few moves of the shovel, and in some cases, especially where there is some cementing material mixed with the sand or gravel, or when the cementing is done by ice in the spring or fall of the year, heavy and dangerous land slides are possible.

From an operating standpoint sand is an ideal material to handle, except when very fine and in heavy winds, in which cases a high pressure stream of water from a hose with spray attachment, if water be plentiful, will greatly help to keep the sand out of the eyes of the men. Sand in a freshly dug bank is quite often naturally moist. In railroad work a good deal of this material is loaded on flat cars with or without sideboards, and it is often difficult to make close estimates of the amounts handled. We have found it an excellent method to weigh the amount of material that will fill a half cubic yard box, at average dryness, and then weigh several trains of cars of the material, which can easily and conveniently be done. From records obtained in 1898, average gravel used for railroad ballast, fair quality, moderately clean, weighed 3248 pounds per yard, rather dry, and the average flat car without sideboards contained 9.4 cubic yards. The length in a train of such average cars was 36 feet center to center of couplers, so that when dumped from the train the ballast averaged 0.26 cubic yard per foot of track. This was sufficient to raise one track 5 inches.

Free running dry sand will not stand up so high in the bucket or on the cars as when it is quite wet or

contains some little cementing material. Therefore, the best performance can be looked for where there is a little cement or water evenly distributed in the bank.

REPORT No. 1 — SHOVEL No. 612

INSPECTED SEPTEMBER 11, 1909

DUNE PARK, IND.

GENERAL CONDITIONS The Knickerbocker Ice Company have this shovel working on some 100 odd acres of sand land at Dune Park, Ind. A large part of this tract has been leveled already. No washing of the material is needed, for it is all of uniform size and exceptionally clean, sharp, white and rather small grained. The bank against which the shovel worked was fully 60 to 70 feet high and sloped at about one on two.

The material was loaded upon gondola cars supplied and spotted by the Lake Shore & Michigan Southern Railway.

TYPE OF SHOVEL The shovel is of the usual 70-ton type with all steel dipper handle and boom, the latter being of the truss type braced on the sides. A 2½-yard dipper is used. This, instead of teeth, has a long steel lip or "cutter blade," so that when filled its capacity is increased to about 3¼ yards. Water is taken from the ground by means of a pipe sunk therein and a pump on the shovel, which is 'igging to water level only.

COST KEEPING The time sheet is made in duplicate and is sent to the main office, where the payroll is made up and the total amount charged to the job. The steam shovel report also goes to the main office every day. This is made out by the steam shovel engineer, but is copied by the clerk to obtain a clean sheet. A facsimile of such a report blank is given on page 46.

At this place is a car repair shop and the work recorded by the use of a system of cards which are made out in duplicate. At the field office the only way to obtain the cost of the repairs for any one car is to go over all the slips and select those pertaining to the car in question.

The requisition blank consists of a form about 6 x 8 inches, similar to that given in "Field System," by Gilbreth. This is in triplicate, one copy for the main office, one for the field, and one for the mechanical engineer at the shop. If the latter have the material wanted on hand he sends it to the job, but if he lack it he copies the requisition, sending it to the purchasing agent, who obtains and ships the goods.

OBSERVATIONS

Weight	70 tons, shipping weight without coal and water
Gauge	Standard
Capacity of dipper	3.27 cu. yds., including lip
Height of lift	9½′
Kind of teeth	None, but steel lip extended 31″
Number of pitmen	4
Height blocked up	6″
Length of boom	28′
Length of dipper handle	18′ 6″
Height of boom above shovel track	24′
Horizontal reach of boom	20′
Farthest dipper can reach to dump	27′
Highest dipper can reach to dump	16′
Diameter of swing circle	7′ 6″
Height of dinkey tracks above shovel tracks	1′

OBSERVATIONS—*Continued*

Depth of dipper (water measure)	51"
Distance inside dinkey track to inside shovel track	21′
Depth of dipper including lip	81½"
Cubic yards excavated (place measure)	3300
Total distance moved forward during day	43′
Number of times moved forward	7
Maximum distance moved forward in one move	6′ 6"
Average distance moved forward in one move	6′ 2"
Average time between beginning of one shovel move and beginning of next	74.7 minutes
Number of cars to one shovel move	16.2
Time shovel is interrupted to change trains	108¾ minutes
Area of section	1500 sq. ft.
Height of face	0 to about 75′
Cubic yards per car (place measure)	average 21.2 yards
Coal cost	$3.00 per ton (Hocking Valley)

Weather clear.

TIME STUDY

	Forenoon	Afternoon
Started work	7:06	1:19
Stopped work	11:48	4:38

Total time worked, 282 + 199 = 481 minutes = 8 hours 1 minute.

	Minutes	Seconds	Per Cent.
Actual working	325	..	67.6
Spotting cars	3	30	0.7
Waiting for cars	108	45	22.6
Moving shovel	32	45	6.8
Miscellaneous delays, including 8 minutes clearing track	11	..	2.3
Total time under observation	481	..	100.0

Direct Labor Distribution Per Day	Standard Basis			
	Loading	Spreading	Incidental	Total
1 runner	5.00	. .	. .	. .
1 craneman	3.60	. .	. .	. .
1 fireman	2.40	. .	. .	. .
3 pitmen	4.50	. .	. .	. .
3 spreaders	. .	4.50	. .	. .
Watchman	. .	. .	1.50	. .
Timekeeper	. .	. .	2.00	. .
Shop engineer	. .	. .	2.00	. .
1 machinist	. .	. .	3.00	. .
1 car repairer	. .	. .	2.00	. .
Total cost of labor per day	$15.50	$4.50	$10.50	$30.50
Cost per cu. yd., cts. . .	0.47	0.14	0.32	0.93
Per cent	50.6	15.0	34.4	100.0

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Per Yd.
	Minutes	Seconds			
Charge to loading					
1. Actual loading . .	325	. .	67.6	0.318	. . .
2. Delays	. .	. .	. .	. . .	. . .
(a) Moving up . . .	32	45	6.8	0.032	0.350
Charge to transportation and dumping					
1. Waiting for cars .	112	15	23.3	0.109	. . .
2. Miscellaneous delays	11	. .	2.3	0.011	0.120
Charge total	481	. .	100.0	. . .	0.470

$$\frac{\text{Incidental labor}}{\text{Direct labor}} = 0.525$$

Form 108-3m-CG&Co-8137

KNICKERBOCKER ICE COMPANY.

STEAM SHOVEL REPORT.

Shovel Number..............

Number Men Worked..........

Number Feet Moved..........

Dune Park,.................................. *190*......

ENGINE					Number of Cars Loaded	TIME LOADING		TIME SWITCHING		DELAYS				REMARKS
ENGINE NUMBER	ARRIVED		DEPARTED							K.I.CO.		R.R.CO.		
	A.M.	P.M.	A.M.	P.M.		Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	
TOTALS														

....*Engineer*

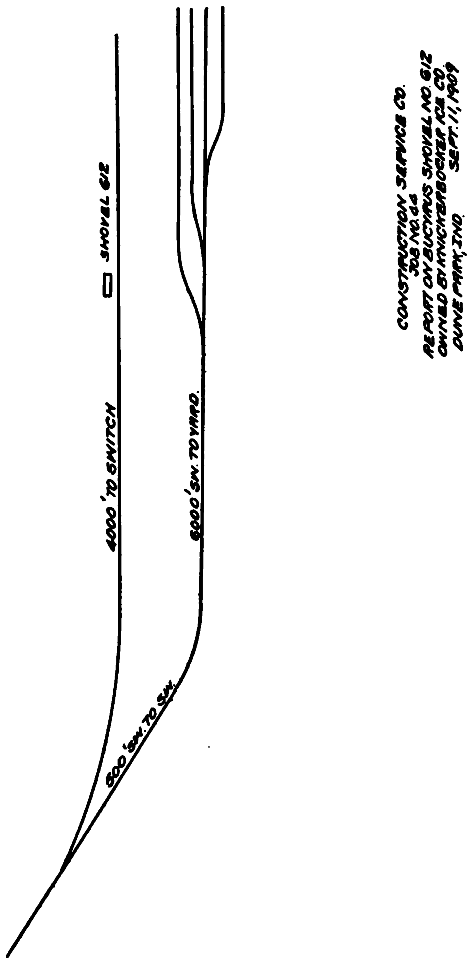

SHOVEL 612
4000' TO SWITCH
6000' SW. TO YARD.
500' SW. TO SW.
CONSTRUCTION SERVICE CO.
JOB NO. 44
REPORT ON BUCYRUS SHOVEL NO. 612
OWNED BY KNICKERBOCKER ICE CO.
DUNE PARK, IND.
SEPT. 11, 1909

Fig. 3. Bucyrus Shovel No. 612 at Dune Park, Ind.

Fig. 4. Bucyrus Shovel No. 1118 at Kent, Ohio.

REPORT No. 2 — SHOVEL No. 1118

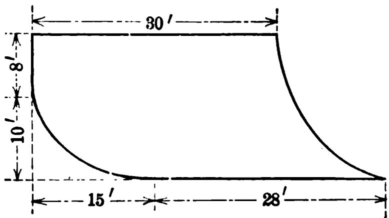
INSPECTED JULY 16, 1909

KENT, OHIO

GENERAL CONDITIONS This work was part of that undertaken in the relocation of the Wheeling & Lake Erie R. R., at Kent, Ohio, and was done by John B. Carter, under contract, and under the personal direction of R. G. Hengst, manager, who may be congratulated on the highly efficient management of this work. The material was uniform in quality, and there was every opportunity to keep the output at its maximum by competition among the men, produced by offering substantial prizes. On the day of inspection a five dollar Panama hat was offered as a prize to the dinkey runner who should average the best time for spotting cars during the afternoon's work. The time was computed from the dumping of the first dipperful into an empty train until the latter started on its way to the dump. This of course included the time of loading by the shovel, and the shovel runner could have "pulled" the race by favoring one of the dinkey runners. As far as could be observed, however, every man did his utmost to make the contest fair and to let the best man win. After five hours' work one of the runners was declared winner of the hat by less than 30 seconds, while the actual loading done was far in excess of what would have been accomplished without such incentive.

The general result of occasional competitions of this kind was to develop an exceedingly efficient field force.

REPAIRS Repairs are anticipated and important parts are kept in duplicate in the storeroom. This shovel and No. 1119 (see page 104) are exactly alike.



Typical Cross Section

OBSERVATIONS

Material is fine gravel with occasional strata of sand. Ideal material to handle. Weather fair after heavy rain during night.

Type of shovel . . . . Standard gauge 70 C
Distance of move . . . On 70-pound short rail sections, 6'
Height of lift . . . . 16' 6"
Size of ties under shovel . . . . 6" x 8' x 8'
Size of bucket . . . . 2½ yards
Age of shovel . . . . New April 1, 1909
Duration of job . . . . 4½ months
Length of shift . . . . 10 hours
Number of shifts per day 1
Water pipe from pumping station
Coal hauled by teams and shoveled into bunkers.
Repairs are made by crew, between shifts, or whenever necessary.
Coal used . . . . 3¾ tons per 24 hours
Water used . . . . 300 gallons per hour
Boiler is cleaned every 3 or 4 weeks . . Very clear water used
Contract price . . . . 25 cts. per yard in embankment
Contract includes embankment.
Narrow gauge track 3', 55-pound rails for cars.
Kind and size of cars used . . . . K. & J., 4 yards
Train is braked by steam on locomotive; by hand on cars.
Kind of signals used, hand by brakeman standing on shovel.
Kind and size of dinkey . . . . Vulcan, 16-ton
Length of haul . . . . Max. 3500', min. 2300'
Number of trains 3
Age of cars and dinkey . . . . 4½ months

TIME STUDY

	Forenoon	Afternoon
Started work	9:32:40	12:02:30
Stopped work	11:32:40	5:02:55

Hrs. Min. Sec. Hrs. Min. Sec.
Total time worked 2 0 0 + 5 00 25 = 7 hrs. 25 sec.

	Minutes	Seconds	Per Cent
Actual working	247	12	58.9
Waiting for cars	31	14	7.4
Moving shovel	55	20	13.2
Miscellaneous delays	(86	39)	(20.5)
Coaling	5	..	1.2
Repairing track	4	45	1.1
Repairing track	3	50	.9
Pulling track on dumps	72	04	17.1
Minor repairs	1	..	.2
Total time under observation	420	25	100.0

Average number of cars loaded per day (average of 85 days) = 516 @ 4¼ yards.

Average number of cubic yards loaded per day (average of 85 days) = 2193.

Direct Labor Distribution Per Day	Standard Basis				
	Loading	Trans-portation	Dump-ing	Inci-dental	Total
1 runner	$5.00	...	...	...	...
1 craneman	3.60	...	...	...	...
1 fireman	2.40	...	...	...	...
3 dinkeymen	...	$7.80	...	...	...
3 brakemen	...	4.50	...	...	...
4 pitmen	6.00	...	...	...	...
9 dumpmen	...	...	$13.50	...	...
1 dump foreman	...	...	2.00	...	...
1 pipeman	...	...	...	$1.50	...
1 smith	...	...	...	2.50	...
1 smith helper	...	...	...	1.50	...
1 watchman	...	...	...	1.50	...
Cost of labor per day	$17.00	$12.30	$15.50	$7.00	$51.80
Cost per day per cubic yard, cents	0.78	0.56	0.70	0.32	2.36
Per cent	33.0	23.7	29.7	13.6	100.0.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Per Yd.
	Minutes	Seconds			
Charge to loading					
1. Actual loading	247	12	58.9	0.459	0.573
2. Delays					
(a) Moving up	55	20	13.2	0.103	
(b) Miscellaneous	6	..	1.4	0.011	
Charge to transporting and dumping					
1. Waiting for cars	31	14	7.4	0.058	0.207
2. Miscellaneous	80	39	19.1	0.149	
	420	25	100.0	...	0.780

Time Study Reductions	Number of Observations	Minimum		Mean		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time for moving up, shovel idle	19	1	20	2	54	5	45
Time between moves, shovel working	20	7	35	12	23	14	..
Time between trains	21	..	55	1	29	2	05
Time per train loading	36	6	07	6	52	8	10
Time per dipper	21	..	16	..	17	..	19
Number of dippers to move	20	24	..	..	42.3	..	48
Number of dippers per train	36	24	..	..	24.2	..	26
Number of dippers per car	432	..	..	..	2.02	..	..

Very interesting light upon one of the competitions, as demonstrating what can be done in uniform material, is given by the following detailed analysis of the above time study.

TIME STUDY

	Forenoon		Afternoon
Started work	9:32:40		12:02:30
Stopped work	11:32:40		5:02:55

	Hrs.	Min.	Sec.		Hrs.	Min.	Sec.		
Total time worked	2	00	00	+	5	00	25	=	7 hours 25 seconds.

(Read from left to right)

Moving Up Shovel Idle	Time per Train	Dippers to Train	Shovel Working Between Moves	Dippers to Move	Time per Dipper	Time Between Trains	Miscellaneous Delays
Min. Sec.	Min. Sec.		Min. Sec.		Sec.	Min. Sec.	Min. Sec.
.. ..	7 35	24	7 35	24	18.90	*. . .	.. ..
5 45	7 50	25	7 50	25	18.75	*. . .	.. ..
5 30	7 40	26	13 15	43	18.50	2 05	.. ..
2 20	8 10	26	.. ..	..	. . .	1 40	.. ..
Contest begins	6 07	24	12 07	44	16 50	1 13	.. ..
1 30	7 25	26	8 20	29	17.20	1 35	.. ..
1 40	7 20	24	10 05	33	18.30	1 50	.. ..
2 00	7 05	24	.. ..	..	. . .	0 55	.. ..
.. ..	6 55	24	10 50	38	17.10	1 25	.. ..
1 20	7 07	24	.. ..	..	. . .	1 23	5 00 coaling
.. ..	6 42	24	9 54	35	16 9	. . .	.. ..
1 53	Noon 29 minutes 50 seconds					*. . .	.. ..
.. ..	6 30	24	.. ..	..	. . .	1 20	.. ..
.. ..	6 30	24	13 00	48	16.20	0 55	.. ..
2 40	6 25	24	.. ..	..	. . .	1 30	.. ..
.. ..	6 55	24	13 20	48	16.65	*. . .	4 45 track
2 00	6 25	24	.. ..	..	. . .	1 20	.. ..
.. ..	7 15	24	13 40	48	17.05	*. . .	.. ..
3 05	6 25	24	.. ..	..	. . .	1 35	.. ..
.. ..	6 51	24	13 16	48	16.55	. . .	3 50
.. ..	6 32	24	.. ..	..	. . .	1 13	72 04 throw-
.. ..	6 32	24	13 04	48	16.30	*. . .	ing track
2 58	6 21	24	.. ..	..	. . .	1 29	on dump
.. ..	6 40	24	13 01	48	16.24	‡0 15	1 00 misc.
3 25	6 20	24	.. ..	..	. . .	1 20	.. ..
.. ..	6 42	24	13 02	48	16.27	‡0 22	.. ..
2 53	7 08	24	.. ..	..	. . .	1 30	.. ..
.. ..	6 39	24	13 47	48	17 20	*. . .	.. ..
2 54	6 17	24	.. ..	..	. . .	1 18	.. ..
.. ..	7 07	24	13 24	48	16.72	‡0 15	.. ..
3 15	6 36	24	.. ..	..	. . .	1 28	.. ..
.. ..	7 17	24	13 53	48	17.34	*. . .	.. ..
3 39	6 48	24	.. ..	..	. . .	1 27	.. ..
.. ..	7 12	24	14 00	48	17 50	‡0 15	.. ..
3 33	6 24	24	.. ..	..	. . .	1 21	.. ..
.. ..	7 00	24	13 24	48	16.72	‡0 15	.. ..
3 00	6 25	24	† 6 25	†24	16.05	. . .	.. ..
Total 55 20	247 12	871	247 12	871	. . .	31 14	86 39
Average 2 54	6 52	$24\frac{1}{8}$	12 23	42.3	17.10	1 25	. . .

12 cars to train. Total cars, 432.

†Left out of averages, because not a full move worked.

‡*Train up during move or at noon or shortly after. Therefore not used in averages.

RESULTS OF CONTEST

As before stated this contest was for the price of a Panama hat to be given to the dinkey engineer who averaged the best time for loading a train, *i. e.*, "loading time."

Dinkey No. 7 Loading Time			Dinkey No. 4 Loading Time			Dinkey No. 3 Loading Time		
Minutes	Seconds	Dip'rs	Minutes	Seconds	Dip'rs	Minutes	Seconds	Dip'rs
6	07	24	7	25	26	7	20	24
7	05	24	6	55	24	7	07	24
6	42	24	6	30	24	6	30	24
6	25	24	6	55	24	6	25	24
7	15	24	6	25	24	6	51	24
6	32	24	6	32	24	6	21	24
6	40	24	6	20	24	6	42	24
7	08	24	6	39	24	6	17	24
7	07	24	6	36	24	7	17	24
6	48	24	7	12	24	6	24 (10)	24
7	00 (11)	24	6	25 (11)	24			
T'l 74	49		T'l 73	54		T'l 67	14	
Av. 6	48		Av. 6	43.09		Av. 6	43.4	
Cars 132			Cars 132			Cars 120		
Dip'rs 264			Dip'rs 266			Dip'rs 240		

	Minutes	Seconds	Per Cent.
Actual working	215	57	72.0
Waiting cars	27	29	9.2
Moving shovel	41	45	13.9
Miscellaneous delays . . .	14	35	4.9
	299	46	100.0

NOTE In the above ratio, the 72 minutes 4 seconds delay due to pulling track on dump is omitted.

The material was ideal for steam shovel work, and as the time study shows, the machine worked with clock-like regularity.

The total loading time of the contest was 215 minutes 57 seconds, and in this time 770 complete dipper swings were made, and 384 cars at 4 cubic yards each were loaded.

Special attention is called to the remarkable closeness of the averages.

It is our understanding that the output shown on page 56, in cars of 4¼ cubic yards capacity, was accomplished during the months designated.

Shovel No. 1118 was moved back on standard rails 30 feet in length, only 6 rails being used, and the method employed was as follows:

When the shovel had finished its cut, a track 90 feet long was laid behind it joining the regular shovel track made up of short sections. The shovel was then backed to the end of this track, and as soon as it had passed off the first rail-length the rails were picked up by four men and thrown over the loading track. On this track stood a dinkey with a 6 by 8-inch piece fastened to its front end, and long enough to extend about 6 feet from the side of the dinkey on the shovel side of the track. At the end of this was a piece of ¾-inch cable, wrapped securely around the timber, and with a loose end about 10 feet long. At the loose end of the cable was a hook made of material small enough to be inserted in the bolt holes in the rail.

When a rail was moved over toward the loading track this hook was fastened to the rail and the dinkey then dragged the rail to the rear of the shovel. While the four men were moving the rails and the dinkey was dragging them, three other men were gathering up the ties and putting them in piles of three or four each, fastening them with chains. The ties were dragged by mule team to a place in rear of the shovel where they

No.	April	May	June	July
1	173	166 dug out	564	552
2		. .	516	108 dug out
3		688	516	312, 3 hrs cost
4		720	492	. .
5	136 starting	800	264	. .
6		752	. .	612
7	387	732	576	552
8	426	752	552	612
9	420	. .	516	600
10		496	moving back	552
11		128 dug out	552	. .
12		672	624	516
13	150 dug out	640	. .	504
14	324 moving back	656	468	492
. .	. . 5 hours	624	492	84 dug out
15	522	. .	564	
16	660	528	408	
17	708	624	576	
18	. .	. .	. .	
19	408	636	468	
20	336	264 dug out	. .	
21	720	300	516	
22	708	564	216 dug out	
23	300	540	336	
24	732	660	588	
25	. .	612	588	
26	708	624	588	
27	780	504	. .	
28	696	564	552	
29	416	264	564	
30	640	. .	552	
31	. .	408	. .	
	10,350	14,918	12,648	

were spaced by two men and made ready to receive the rails. As soon as sufficient ties for a rail length of track were laid, the rails that had just been brought back by the dinkey were placed upon them and fastened to the rails on which the shovel stood, and were connected and spaced by four regular track bridles. The shovel then moved back one rail length and so left a rail length in front of its position uncovered, this being then torn up and moved back—the rails by the dinkey and the ties by the mules.

The force engaged included the

Shovel engineer	1 Mule team and driver
Craneman	8 Men moving rails
Fireman	5 Men moving ties
Dinkey engineer	4 Pitmen bolting track, etc.
Dinkey brakeman	
1 Foreman	

at a total labor cost of $46.60 per day.

It took 1 hour 10 minutes, to move the shovel back 300 feet in this manner or .1167 of a day.

0.1167 x $46.60=$5.44 to move 300 feet or 1.81 cents per foot.

Preparatory cost was $1500; includes moving shovel 2500 feet from railroad tracks on practically same grade as bottom of pit.

Distance of move in pit laterally for each bank averages 30 feet for eleven moves.

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{60{,}000}{7{,}500} = 8.00.$$

REPORT No. 3 — SHOVEL No. 611

INSPECTED SEPTEMBER 14, 1909

GARY, IND.

GENERAL CONDITIONS The Pennsylvania Railroad, as part of the improvement of its lines west of Pittsburgh, is abolishing grades at South Chicago. The contract for excavating and placing the earth for this embankment is in the hands of P. T. Clifford & Sons, of Valparaiso, Ind., while everything else, including concrete and timber work, is being done by the Brownell Improvement Company of Chicago, Ill.

Sand is used for the filling and is taken from a sand pit owned by Mr. Clifford and located at Gary, Ind., and steam shovel Bucyrus No. 611 is occupied in loading this sand into cars supplied by the Pennsylvania Railway and transported by them a distance of 15 miles over their main line to the fill at South Chicago.

THE SHOVEL The steam shovel itself has no features that would distinguish it from any of the others of the 70-ton class, but the method of blocking up the rear trucks is different from the usual practice. These are raised 20 inches while the front ones are elevated only the usual 6 inches. The reason given for this by the runner was that the boom "swung better." When it is swung loaded over the cars it can be stopped more quickly and will swing back in less time than when blocked evenly. The boom is of the truss type with lattice side bracing, and both it and the dipper handle are made entirely of steel. Water was taken from the locomotive.

PLANT ARRANGEMENT As indicated by the sketch, the Pennsylvania Railroad maintains a small yard at this point. The arrows show

the direction taken by loaded and empty cars. Two large freight locomotives were kept in this yard to haul the trains to the main line. Two road locomotives hauled from the siding to the fill in South Chicago. A small shop containing a boiler to supply steam for the pump that forces water into the tank, a drilling machine, and a few hand tools are also maintained here by the railroad.

At the fill in South Chicago the sand is shoveled from the cars by some 50 Italian laborers, and after the train pulls out, a side scraper levels off the bank.

OBSERVATIONS

Type of shovel	70-ton
Gauge track standard	
Capacity of dipper	3 cu. yds
Height of lift	7′
Kind of teeth	Extended lip
Number of pitmen	4
Height blocked up rear trucks, 20″; front trucks	6″
Length of boom	28′ 0″
Length of dipper handle	18′ 6″
Height of boom above pivot	18′ 8″
Height of boom above shovel track	23′ 8″
Horizontal reach of boom	21′ 6″
Farthest dipper can reach to dump	28′
Highest dipper can reach to dump	16′
Diameter of bull wheel	7½′
Height of dinkey tracks above shovel tracks	8″
Distance inside dinkey tracks to inside shovel track	20′
Depth of dipper (water measure)	50½″
Depth of dipper, including lip	71″
Total distance moved forward during day	44′
Number of times moved forward	7
Maximum distance moved forward in one move	7′ 4″
Average time between beginning of one shovel move and beginning of next	60.7 min.
Number of cars to one shovel move	10.8
Time shovel is interrupted to change train	267 min.
Area of section	755 sq. ft.
Height of face	24′ to zero
Cubic yards per car	21.1 place measure (average)
Weather, clear	

TIME STUDY

	Forenoon	Afternoon
Started work	7:09	12:48
Stopped work	12:00	5:04

Total time worked . . 291 + 256 = 547 minutes = 9 hours 7 minutes.

	Minutes	Seconds	Per Cent
Actual working	193	30	35.4
Spotting cars	1	30	0.3
Waiting for cars	267	00	48.8
Moving shovel	28	00	5.1
Miscellaneous delays . . .	7	00	1.3
Idle–engineer looking after fire	21	00	3.8
Pitmen loosening bank . .	1	00	0.2
Waiting for cars to pull out .	2	00	0.4
Fixing valve on crane engine	6	00	1.1
Taking water	10	00	1.8
Taking coal	10	00	1.8
Total time under observation	547	00	100.0

THE SHOVEL CREW PAY ON STANDARD BASIS

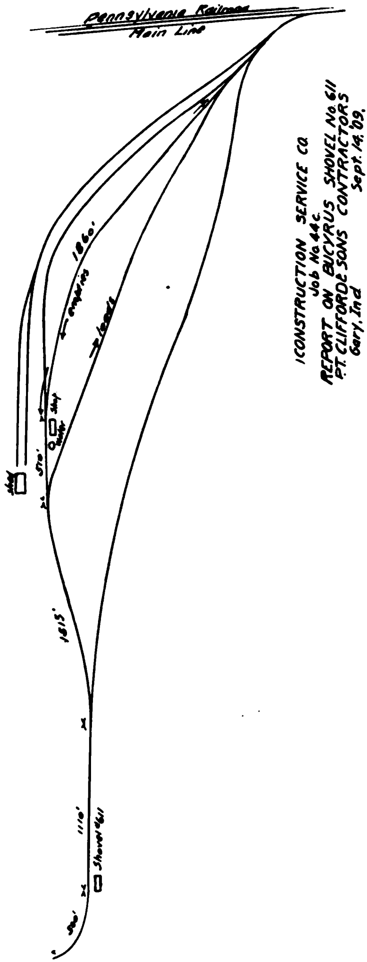
Runner	\$5.00
Cranemen	3.60
Firemen	2.40
4 pitmen	6.00
6 trackmen	9.00
Labor cost per day for excavating.	\$26.00

Cubic yards loaded on day of observation 1602

Cost of loading per cubic yard (direct labor only), $\frac{\$26.00}{1602} = 1.62$ cents per cubic yard.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard
	Min.	Sec.			
Charge to waiting for blasters	1	. .	0.2	0.003	0.003
Charge to loading					
1. Actual loading . .	193	30	35.4	0.574	0.796
2. Delays					
a Moving up . .	28	. .	5.1	0.083	
b Repairs . . .	6	. .	1.1	0.018	
c Miscellaneous .	41	. .	7.5	0.121	
Charge to transportation and dumping					
1. Waiting for cars . .	270	30	49.4	0.800	0.821
2. Miscellaneous . .	7	. .	1.3	0.021	
	547	00	100.0		1.620

Fig. 5. Dipper used on Shovel No. 611



Pennsylvania Railroad
Main Line
1860'
1815'
1110'
Shovel No. 611
CONSTRUCTION SERVICE CO.
Job No. 44c.
REPORT ON BUCYRUS SHOVEL No. 611
PT. CLIFFORD E SONS CONTRACTORS
Gary, Ind
Sept. 14, '09.

Figs. 6 and 7. Two Views of 70-ton Bucyrus Steam Shovel on Pennsylvania Railroad Improvement, South Chicago

REPORT No. 4 — SHOVEL No. 166

INSPECTED SEPTEMBER 12, 1909

SOUTH BEND, IND.

LOCATION OF WORK Shovel No. 166 is located about 5 miles outside of South Bend, Ind., at what is locally known as Ruple's Pit. This is a gravel pit and was originally worked by the Lake Shore & Michigan Southern Railway, having been bought by them from Mr. Ruple at a cost of $115 an acre for 140 acres, 125 of which are estimated as sand, the remainder being swamp land. The pit is now leased by the Knickerbocker Ice Company. It is an uncemented gravel, similar to that found in dunes throughout New York state. It contains a sharp sand that is very clear, leaving practically no dirt when rubbed in the palm of the hand.

THE SHOVEL The shovel is of a very old 45-ton crane type. The boiler is vertical. The swing circle is located at the top instead of the bottom of the boom mast and is 10 feet in diameter, the swinging chain passing over the roof and through it to the drum. The crane is a triangular truss, the mast consisting of a solid casting 9½ feet high. The lower and upper chords of the crane are composed of channels 3 x 10 inches braced vertically by angles. There is no thrusting engine on this machine, the dipper being held to the face by the hoisting engine and by a foot friction brake on the large gear wheel at the shipper shaft. It is operated by the craneman, who releases the brake when the dipper is in position to begin digging, and applies it a soon as the dipper touches the ground, holding it there while the hoisting chain draws it through the bank. This arrangement is more fatiguing to the craneman than is the crane engine, but in spite

of this fact, and notwithstanding that the craneman was just learning to operate the shovel, good time was made. The dipper is correspondingly small, holding 1.25 cubic yards water measure, but as the lip projects out 18 inches and consists of a plain piece of 1¼-inch steel extending half way up the side of the dipper, the capacity is increased to about 1.9 cubic yards.

PLANT, ARRANGEMENT, HANDLING OF MATERIAL

Only half the plant is being operated, the labor force consisting of 16 men with but one locomotive and a 45-ton shovel.

The sketch shows the storage yard and the method of hauling to the washer. The track is all standard gauge and the length of haul is about 2100 feet. A 50-ton locomotive was used and hauled one bottom dump car of 31 cubic yards capacity. There was no alternate train and consequently the shovel was idle a large part of the time.

Fig. 8. Shovel No. 166 at South Bend, Ind.

ADDITIONAL NOTES Water is obtained by driving a pipe with the usual point and filter to a depth of about 6 feet and drawing the water up by means of a pump on the shovel, which is digging to the water level only. Pools of water sometimes form in front of it, but these are filled with sand as fast as they appear.

The hinge of the dipper is at its side.

OBSERVATIONS

Gauge	Standard
Height of lift	9′
Kind of teeth	None—extended lip
Height blocked up	1′
Length of boom	24½′
Length of dipper handle	13′
Height of boom above pivot	14′ 9″
Height of boom above shovel track	19′
Horizontal reach of boom	19′ 7″
Farthest dipper can reach to dump	22′
Highest dipper can reach to dump	13′, plus or minus
Diameter of swing circle	10′
Height of dinkey tracks above shovel tracks	1′
Distance inside dinkey tracks to inside shovel tracks	15′ 7″
Depth of dipper (water measure)	22″
Depth of dipper, including lip	40″
Depth of dipper, including teeth	No teeth
Height of boom post	9′ 4″
Number cars loaded	12
Cubic yards excavated (place measure)	373
Total distance moved forward during day	29′
Number of times moved forward	5
Maximum distance moved forward in one move	6′ 4″
Average time between beginning of one shovel move and beginning of next	96.5 minutes
Number of cars to one shovel move	2.4
Time shovel is interrupted to change train	379¼ minutes
Area of section about	450 square feet
Height of face	14′
Average yardage, place measure, per car	31

Coal costs $3.00 a ton at shovel and is Hocking Valley.

Weather cloudy.

TIME STUDY

	Forenoon	Afternoon
Started work	7:54	12:30
Stopped work	11:31	6:01

Total time worked 217 + 331 minutes = 548 minutes = 9 hours 8 minutes.

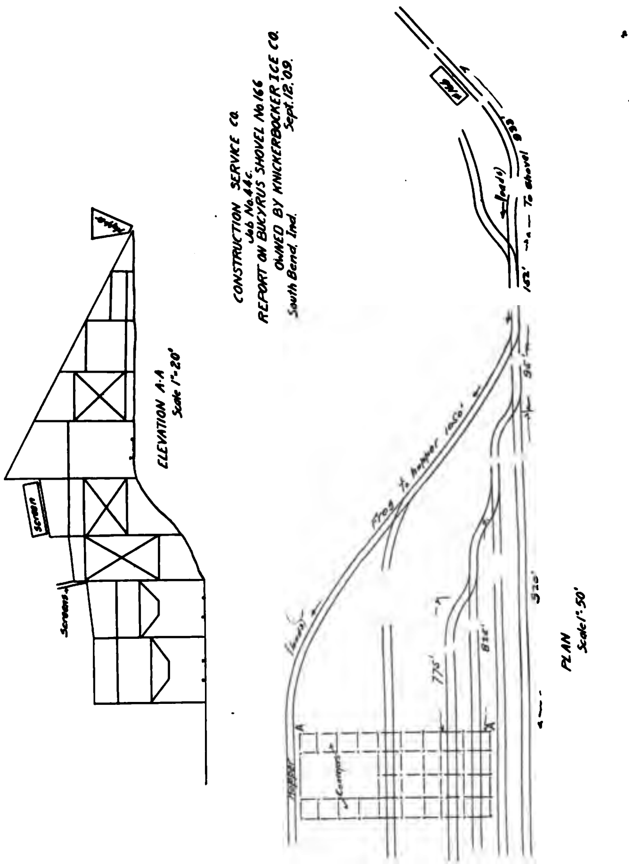
	Minutes	Seconds	Per Cent.
Actual working	123	15	22.5
Spotting cars	...	..	...
Changing trains	379	15	69.2
Moving shovel	35	..	6.4
Miscellaneous delays	8	..	1.4
Idle—Setting key in shipper shaft	2	30	0.5
Total time under observation	548	..	100.0

Direct Labor Distribution Per Day	Standard Basis				
	Loading	Transporting	Spreading	Incidental	Total
Runner	$5.00	...	...	...	...
Craneman	3.60	...	...	...	...
2 pitmen	3.00	...	...	...	...
1 washer runner	...	...	$2.00	...	...
1 man at locomotive hopper	...	...	1 50	...	...
1 man at washer	...	...	1.50	...	...
3 carmen	...	$4.50	...	...	...
1 car patcher	...	1.50	...	...	...
1 pumpman	...	...	...	$1.50	...
1 watchman	...	...	...	1.50	...
1 locomotive engineer	...	2.60	...	...	...
Total cost of direct labor per day	$11.60	$8.60	$5.00	$3.00	$28.20
Cost direct labor, cubic yard, cts.	3.11	2.31	1.34	0.80	7.56
Per cent	41.1	30.6	17.7	10 6	100.0

Note.—By the locomotive hopper is meant the hopper into which the material is dumped from the cars. The bottoms of the cars are lined with hay to hold the sand.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Minutes	Seconds			
Charge to waiting for blasters	3	. .	0.5	0.016	0.016
Charge to loading					
1. Actual loading . .	123	15	22.5	0.700	. . .
2. Delays					
a Moving up . . .	35	. . .	6.4	0.199	0.943
b Repairs	2	30	0.5	0.016	. . .
c Miscellaneous . .	5	. . .	0.9	0.028	. . .
Charge to transporting and dumping					
1. Waiting for cars .	379	15	69.2	2.151	2.151
	548	. . .	100.0	. . .	3.110

Fig. 9. 1¼-yard Bucket with 18-inch Lip added, Increasing Capacity to about 2 Yards, 45-ton Type, near South Bend, Ind.


CONSTRUCTION SERVICE CO.
Job No. 44c.
REPORT ON BUCYRUS SHOVEL No. 166
OWNED BY KNICKERBOCKER ICE CO.
South Bend, Ind.
Sept. 12, '09.
ELEVATION A-A
Scale 1"=20'
Screen
Screens
Frog to hopper 1050'
To shovel
152'
775'
PLAN
Scale 1"=50'

REPORT No. 5 — SHOVEL No. 58

INSPECTED SEPTEMBER 24–25, 1909

JANESVILLE, WIS.

LOCATION In addition to its plant at South Bend, Ind. (see p. 64), the Knickerbocker Ice Company has a gravel pit and washer at Janesville, Wis. These two plants present several points of difference, in some instances the conditions being exactly reversed.

GENERAL CONDITIONS The pit is located about two miles east of Janesville and on the line of the C., M. & St. P. Railway, which has a siding to the washer. The material consists of a clean coarse cemented gravel containing considerable sand. This is excavated by a 45-ton steam shovel and loaded into three-yard standard gauge steel cars which are hauled to the bottom of an inclined plane by means of horses. Two cars only are used. From the bottom of the incline they are hauled by cable to the hopper in the tower at the top, where the material is dumped from the car automatically. The car is then lowered and hauled back to the shovel by the horse.

THE SHOVEL The material is easy to dig, and the shovel had no difficulty in making rapid progress. It is of a very old type, the number 58 indicating that it was one of the first put on the market by the Bucyrus Company. It is now twenty-two years old, but is in good condition and is well adapted for this light work. Like No. 166 at South Bend, the swing circle is at the top of the boom post and the crane consists of a triangular truss.

The shovel was not worked to its full capacity, as will be understood when it is stated that it spent but 18 per cent. of the day in actual loading, the remainder,

82 per cent., being in waiting for cars and making repairs to the washer.

COST KEEPING The time cards used here are like those used at Dune Park. The superintendent stated that every Sunday during the season is spent in making repairs to the plant and shovel. The labor cost would therefore be very great, although the material cost is not excessive.

GENERAL The operation of turning the hoisting cable on the inclined runway end for end occupied 6 men for 38 minutes at a cost of 69 cents, but the entire plant was shut down in the meantime.

OBSERVATIONS

Weight	45 tons
Gauge	Standard
Capacity of dipper, 1.22 cubic yards, water measure; 1¾ yards including lip.	
Height of lift	6′
Kind of teeth	Steel plate lip square at the corners
Number of pitmen	2
Height blocked up	6″
Length of boom	22′ 6″
Length of dipper handle	13′
Height of boom above pivot	15′
Height of boom above shovel track	18′ 8″
Horizontal reach of boom	16′
Farthest shovel can reach to dump	22′
Highest shovel can reach to dump	13′
Shovel can cut below track	3½′
Diameter of swing circle	9′
Depth of dipper (water measure)	40½″
Depth of dipper, including lip	65½″
Height of boom post	8′ 6″
Number of cars loaded	120
Cubic yards excavated	about 360
Total distance moved forward during day	None
Number of times moved forward	None

OBSERVATIONS—*Continued*

Area of section	about 1300 square feet
Height of face	55′
Coal used	about ½ ton
Water used	74 cubic feet
Coal cost	$1.85 at mines

TIME STUDY

	Forenoon	Afternoon
Started work	7:08	12:50¼
Stopped work	11:57¼	4:50

Total time worked 4 Hr. 49¼ Min. + 3 Hr. 59¾ Min. = 529 minutes, = 8 hours 49 minutes.

	Minutes	Seconds	Per Cent
Actual working	96	15	18.2
Spotting cars	. . .	. . .	. . .
Waiting for cars	334	30	63.2
Moving shovel	. . .	. . .	. . .
Idle			
Repairing broken strand in hoisting cable on inclined plane	9	15	1.8
Repairing harness	1	. . .	0.2
Turning cable on inclined plane end to end . . .	37	45	7.1
Repairing broken strand in hoisting cable on inclined plane	35	45	6.8
Putting car on track . . .	5	. . .	0.9
Repairing car	9	30	1.8
Total time under observation .	529	. . .	100.0

Direct Labor Distribution Per Day	Standard Basis				
	Loading	Trans-porting	Spread-ing	Inci-dental	Total
Superintendent	...	...	...	$6.00	...
Timekeeper	...	...	...	2.00	...
Night watchman	...	...	...	1.50	...
Runner	$5.00	...	...	...	...
Craneman	3.60	...	...	...	...
1 car loader	1.50	...	...	...	...
1 bank caver	1.50	...	...	...	...
Track boss	...	$2.00	...	...	...
Crusherman	...	...	$1.50	...	...
Towerman	...	...	1.50	...	...
2 drivers	...	3.00	...	...	...
Fireman	...	...	1.50	...	...
Screenman	...	...	1.50	...	...
3 horses	...	4.50	...	...	...
Total cost direct labor per day	$11.60	$9.50	$6.00	$9.50	$36.60
Cost direct labor per cubic yard	3.22	2.64	1.67	2.64	10.17
Per cent	31.6	2.60	16.4	26.0	100.00

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard
	Min.	Sec.			
Charge to loading					
1. Actual loading	96	15	18.2	0.586	0.586
Charge to transportation and dumping					
1. Waiting for cars	334	30	63.2	2.035	2.634
2. Repairs for cars	55	30	10.6	0.338	
3. Miscellaneous for cars	42	45	8.0	0.261	
	529	00	100.0		3.220

DAYS WORKED AND CARS LOADED DURING LAST SIX MONTHS

Month	Days	Cars
April	23	303
May*	22	278
June	26	354
July	26	349
August	26	346
September 1st to 24th inclusive	18	286
Total (average, 13.6 cars per day)	141	1916

* There were several washouts during this month, part of the time being spent in making repairs due to this cause. The cars were freight gondolas loaded ready for transportation, and averaged about 20 cubic yards capacity.

	Loading	Trans-porting	Spread-ing	Inci-dental	Total
Cost direct labor per day (average, six months) per cubic yard, cents	4.27	3.49	2.02	3.49	13.45
Percentage (six months)	31.7	25.95	16.4	25.95	100.0

Process Analysis Average of Six Months	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard
	Min	Sec.			
Charge to loading					
1. Actual loading	96	15	18.2	0.778	0.778
Charge to transportation and dumping					
1. Waiting for cars	334	30	63.2	2.698	3.492
2. Repairs for cars	55	30	10.6	0.452	
3. Miscellaneous for cars	42	45	8.0	0.342	
	529	00	100.0		4.270

TRANSPORTATION

	Obs.	Shovel to Bottom of Plane			At Bottom of Plane			Bottom of Plane to Top of Plane			At Top of Plane		
		Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
Time (seconds)	8	69	72	75	23	36.6	50	39	42.7	55	3	4.2	6
Distance (feet)	8	435	435	435	. .	. .	. .	275	275	275	. .	. .	. .
Speed (feet per second) . .	8	5.8	6.1	6.3	. .	. .	. .	5.0	6.4	7.0	. .	. .	. .

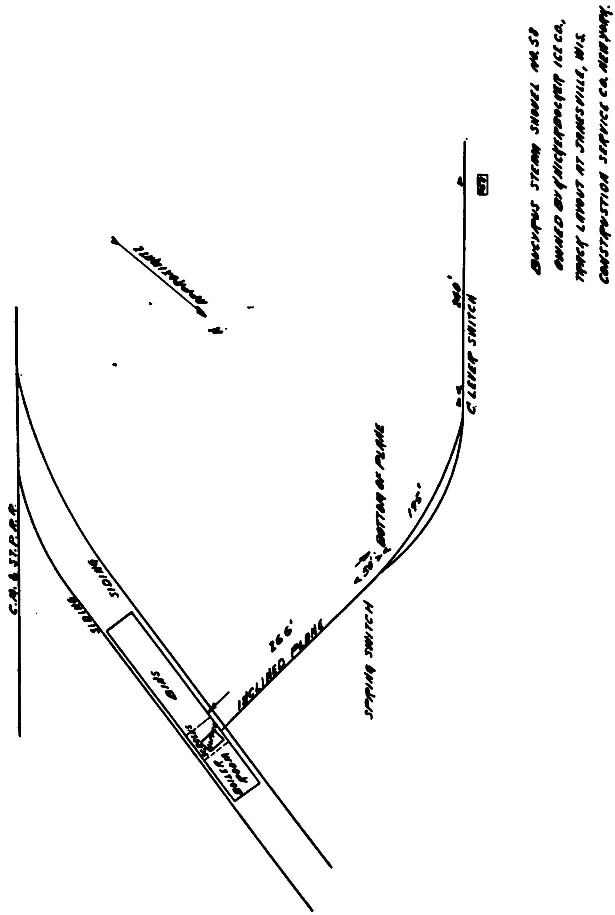
	Obs.	Top of Plane to Bottom of Plane			At Bottom of Plane			Bottom of Plane to Shovel			Time for Round Trip		
		Min.	Ave.	Max.	Min	Ave	Max.	Min.	Ave.	Max.	Min.	Ave.	Max
											M.S.	M.S.	M.S.
Time (seconds)	8	17	20.5	25	20	59.9	85	70	78.1	87	4.53	6.20	12.5
Distance (feet)	8	275	275	275	. .	. .	. .	435	435	435	. .	. .	. .
Speed (feet per second) . .	8	11	13.4	16.2	. .	. .	. .	5.0	5.5	6.2	. .	. .	. .

Average time for round trip from daily log, 7 minutes 20 seconds (120 obs.)

ACTUAL RATIOS

$$\frac{\text{Superintendence}}{\text{Direct labor}}=0.150 \qquad \frac{\text{Incidental labor}}{\text{Direct labor}}=0.145$$

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}}=\frac{4625}{1000}=4.625$$


BUCYRUS STEAM SHOVEL NO. 58
OWNED BY KNICKERBOCKER ICE CO.
TRACK LAYOUT AT JANESVILLE, WIS.
CONSTRUCTION SERVICE CO. NEW YORK.
C.M. & ST.P.R.R.
SIDING
SIDING
BINS
INCLINED PLANE
266'
SPRING SWITCH
BOTTOM OF PLANE
175'
C LEVER SWITCH
200'

Figs. 10 and 11. Shovel and Inclined Plane at Janesville, Wis.

CHAPTER VI

STEAM SHOVEL WORK IN EARTH AND GLACIAL DRIFT

The peculiarity of this material for steam shovel work is that it varies much more in consistency than sand and gravel, may be difficult to break up, and often contains boulders of considerable size. It is the usual practice to attack it with teeth instead of a steel lip on the bucket. When wet, the material is likely to stick to the bucket, and particularly to the bottoms of dump cars, making it difficult to remove in dumping, and being likely to dry or freeze into a hard cake. For this reason it is important to clean and scrape car bottoms at night.

Because of the prevalence of boulders, which cause irregular loading of the bucket and of the cars, this material will not be likely to average quite as many yards, place measure, per car of the same size as will sand or "good" gravel.

When the large boulders occur, necessitating the use of chains and hooks, or even mud capping with dynamite to reduce their size, the work is necessarily much delayed and the cost becomes excessive.

Sometimes a good sized boulder may roll down the slope and injure one of the pitmen, who are therefore more cautious than when working in sand, and consequently slower.

In estimating upon this material the ground should be gone over with care by the man who is to make the estimates, and a computation made of the number of boulders above the limiting size that are likely to be encountered. A shovel with large bucket is advisable for this work, since the delays from boulders are thus minimized.

the move back to enter a new cut is made continuous. This necessitates an unbroken track behind the shovel. In this particular case it took all morning and part of the afternoon to thus clear the way and lay the ties and rails. The time required for such a process is of course dependent on the distance the shovel must be moved back and also upon the number of curves encountered. Great care should always be exercised in having the bridle rods in proper adjustment, especially on the curves, for otherwise the shovel will be likely to leave the track, causing annoying delays. Here, as will be seen in the "Time Study," the actual moving back occupied 106 minutes, and 48½ minutes were necessary to get things into running order after the backward journey.

SUPPLIES Coal for the shovel was brought in by the dinkeys, dumped near by, and carried to the dump by a laborer. For this purpose an empty nail keg was used, and by having the man keep count of the number of kegs, the consumption to within ... of a ton was obtained. On the first day this amounted to 2.2 tons and on the second to 2.7 tons. Water was supplied through a pipe carried from the ... at a distance, and there was no method of measuring it.

The amount of oil and cotton waste used was also ...

METHODS EMPLOYED BY CONTRACTOR In order to be able from time to time to tell whether the work was costing more that it should, the ... in charge has kept very close cost accounts, and kindly explained his methods.

The timekeeper on this work has two books, using ... daily. He does not write in the names or

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The peculiarity of this material for steam shovel work is that it varies much more in consistency than sand and gravel, may be difficult to break up, and often contains boulders of considerable size. It is the usual practice to attack it with teeth instead of a steel lip on the bucket. When wet, the material is likely to stick to the bucket, and particularly to the bottoms of dump cars, making it difficult to remove in dumping, and being likely to dry or freeze into a hard cake. For this reason it is important to clean and scrape car bottoms at night.

Because of the prevalence of boulders, which cause irregular loading of the bucket and of the cars, this material will not be likely to average quite as many yards, place measure, per car of the same size as will sand or "good" gravel.

When the large boulders occur, necessitating the use of chains and hooks, or even mud capping with dynamite to reduce their size, the work is necessarily much delayed and the cost becomes excessive.

Sometimes a good sized boulder may roll down the slope and injure one of the pitmen, who are therefore more cautious than when working in sand, and consequently slower.

In estimating upon this material the ground should be gone over with care by the man who is to make the estimates, and a computation made of the number of boulders above the limiting size that are likely to be encountered. A shovel with large bucket is advisable for this work, since the delays from boulders are thus minimized.

REPORT No. 6 — SHOVEL No. 893

INSPECTED JULY 14 and 15, 1909

LONG ISLAND CITY, N. Y.

GENERAL CONDITIONS The Pennsylvania Railroad is building a large storage yard about 1000 feet wide by 8000 feet long at Long Island City to be used for passenger cars only. This is the so-called "Sunnyside yard" and connects with the main terminal at 34th Street, New York City, by means of tunnels under the East River and Manhattan Island.

The excavation required to make this area level has been through the same glacial drift that is found over Long Island, and has necessitated the removal of thousands upon thousands of yards of material. Three and four steam shovels have been employed on this work, which is being done by the Degnon Realty and Terminal Improvement Company, of 60 Wall Street, New York City.

At the time of the inspection of Bucyrus Shovel No. 893 the work was nearing completion, the stone crusher was being dismantled, the machinery overhauled and only one shovel (No. 893) was working. Two days were spent in timing the different operations and collecting miscellaneous data.

DESCRIPTION OF SHOVEL AND METHODS OF OPERATION Shovel No. 893 has standard gauge railroad car wheels, weighs seventy tons, and is about three years old. It has been overhauled several times and is in good condition. It happened, however, that at the time of the inspection considerable repairing was necessary. When first observed the shovel was laid up for 45 minutes because of the breaking of the valve stem on the hoisting engine, and the next day 1 hour was spent in replacing

the U-bolt on the dipper handle. Both these parts are likely to break on any machine, particularly when the nuts are not screwed up tight. The machine is equipped with an all-steel boom and dipper handle.

The dipper has been remodeled, so that it now has a capacity of 2.66 cubic yards water measure. It is of the usual design and is provided with removable manganese teeth. Shortly before closing down on the first day of our observation one of these teeth broke at its base. The breakage did not delay the shovel, but it required five men 3 hours (overtime) to make the necessary repairs.

It will be noticed under the "Labor Distribution" table that there are two more pitmen than is usual. The duties of the engineer consist in superintending everything about the shovel in a general way and, in co-operation with the craneman, running the shovel. His word is law in anything connected with the shovel. The craneman operates the dipper engine and dumps the dipper. He also directly supervises the operation of moving forward, but on this shovel did none of the actual work. The pitman receiving $1.75 is a general handy man and is foreman of the pitmen, although he does the same work as they.

While the shovel is operating, the pitmen are engaged in taking up the rails and ties behind it and carrying them to a convenient place ahead, so that they can be readily laid. The ties are thrown in front of the forward trucks, and as soon as the dipper digs high and far enough away, the pitmen lay the stringers and then roll the ties into place so that as soon as the shovel is ready to move, all that remains to be done is to place and clamp them to the rails, and set the jacks. Under the head of "Time Study" will be found the percentage of the total time consumed in moving forward.

As has been explained, moving the shovel forward is an intermittent process. So far as is possible, however,

the move back to enter a new cut is made continuous. This necessitates an unbroken track behind the shovel. In this particular case it took all morning and part of the afternoon to thus clear the way and lay the ties and rails. The time required for such a process is of course dependent on the distance the shovel must be moved back and also upon the number of curves encountered. Great care should always be exercised in having the bridle rods in proper adjustment, especially on the curves, for otherwise the shovel will be likely to leave the track, causing annoying delays. Here, as will be seen in the "Time Study," the actual moving back occupied 106 minutes, and 48½ minutes were necessary to get things into running order after the backward journey.

SUPPLIES Coal for the shovel was brought in by the dinkeys, dumped near by, and carried from the dump by a laborer. For this purpose an ordinary nail keg was used, and by having the man keep count of the number of kegs, the consumption to within a tenth of a ton was obtained. On the first day this amounted to 2.2 tons and on the second to 2.7 tons.

Water was supplied through a pipe carried from the city mains at a distance, and there was no method of measuring it.

The amount of oil and cotton waste used was also indeterminate.

GENERAL METHODS EMPLOYED BY THE CONTRACTOR In order to be able from time to time to tell whether any part of the work was costing more that it should, the engineer in charge has kept very close cost accounts, and he very kindly explained his methods.

The time keeper on this work has two books, using them alternately. He does not write in the names or

the numbers of the men before leaving the office, but as he finds the men on the work he jots their numbers or names one below the other just as he comes to them, starting with a new page every day. The following day this book is left in the office and the clerical force compares the timekeeper's record with the foreman's reports. If there is any discrepancy it is called to the timekeeper's attention and he looks into the matter.

From these records the office force makes up a daily statement showing the labor employed, the rate of wages, the amounts, and the nature of the work. Material used is kept account of by the amounts delivered to each machine or foreman, as shown by the storekeeper's daily report.

From these reports the engineer himself makes up the distribution. This, however, does not follow any definite scheme such as the schedule employed by the Construction Service Company, but consists in crediting to each item, such as grading, surfacing, mixing concrete, shovel No. 1, etc., its quota of labor and materials used, and from these data the unit costs are computed by the engineer, so that no one else has access to them. Superintendence, insurance, interest, and other items that cannot be charged directly to any one operation are distributed according to the percentage of the total labor cost involved. Superintendence has been found to be about 6 to 6½ per cent of the labor cost. The cost and amount of coal, oil, and cotton waste supplied to any machine over a definite period is divided by the number of working days and by the number of yards excavated or hauled to find the unit quantities and costs. Depreciation is not considered until the end of the job. With the exception of the foreman's reports and the daily statement of the timekeeper, no printed forms are used for this work.

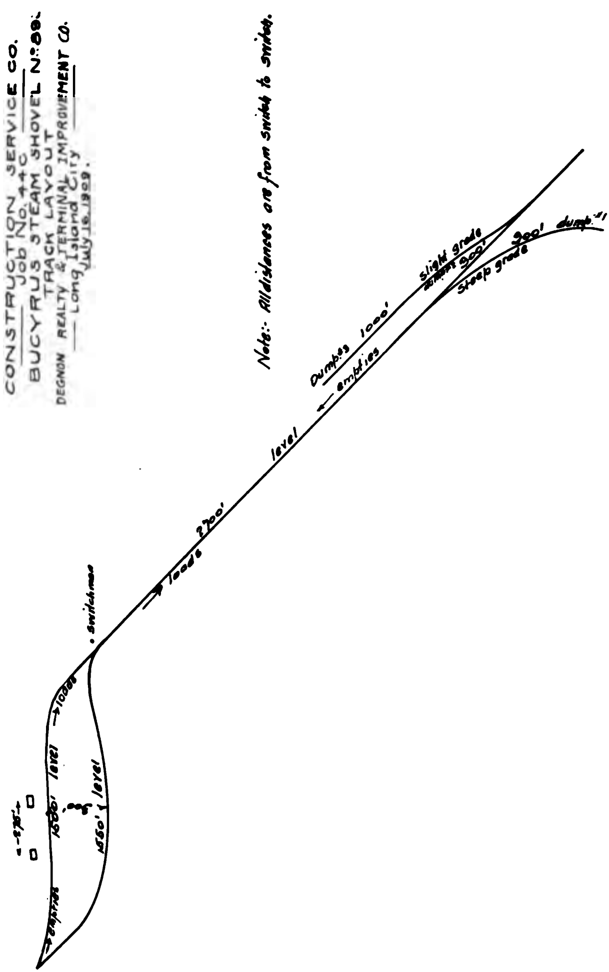
The general plan of the track layout, shown on page 84, is the ideal arrangement for feeding cars to a

shovel, as, with wideawake signalmen and dinkey engineers and plenty of cars, there should be no more reason for losing time in spotting trains than in spotting cars, for as soon as a train is loaded and pulls out another follows right into its place, and by loading the end car first no time need be lost. With the exception of not always having enough trains on hand, this is what happened on this work, and when the trains did follow one after another very little time was lost. This arrangement is particularly suitable when the number of moves of the shovel is a minimum, for then the idle time of the dinkeys would be a minimum also.

The total "runaround" was 7300 feet, 6600 feet and 6300 feet, depending upon the dump, as indicated in the sketch. The dinkeys weighed 18 tons each and the cars were the usual 4.17-yard side dump cars, as shown in the various illustrations. These cars hold about 3.6 cubic yards when heaped full, according to the engineer's estimate. No method of braking was provided or needed, as the only steep grades were those leading to the various dumps, and these were very short. The act of dumping these cars was performed by the laborers placing their shoulders to the under side and tilting them over.

TIME STUDY A minute and accurate record of the working of the shovel was kept for two consecutive days, and, because of certain features of the work, it furnishes some interesting data and comparisons. The times required for all the movements of the shovel and for all delays, the amount of coal used and the number of men employed, were recorded. For the sake of brevity this has been set down in tabular form.

The material consisted of glacial drift, part of which was very loose and part comparatively well cemented. Those illustrations showing the face of the bank distinctly


CONSTRUCTION SERVICE CO.
Job No. 440
BUCYRUS STEAM SHOVEL No. 89.
TRACK LAYOUT
DEGNON REALTY & TERMINAL IMPROVEMENT CO.
Long Island City
July 16, 1909.
Note:- All distances are from switch to switch.
Dumps 1000'
empties
level
2700'
loads
switchman
slight grade
900'
steep grade
900' dump
loads
level
level
1550'
empties

indicate a pebbly layer about ten feet wide with sand on the top and bottom. This stratum in places was very hard, but the sliding of the ground above it several times obviated the necessity of moving forward.

A feature of the data given in a following table is the large percentage of time required for handling boulders. The superintendent explained that, as the material was being used for dressing and one of the dumps was alongside the main line tracks, the boulders could not be loaded. On the previous run they had been cast behind the shovel and lined the foot of the embankment, as shown very clearly in Fig. 13. There were some seventy-five of these in front of the shovel after it was moved back, and they, of course, all had to be moved again on the new run.

Under "Time Study," second day, is an item of 36½ minutes for clearing track after a blast. The cause of this is distinctly shown in Fig. 15, where it is seen how the blast loosened the earth so that it slid down upon the dinkey tracks.

The time for a round trip, given under "Observations," is an average as indicated by the difference in time between the departure of the train and its return to the shovel. In some instances this includes "waiting on the shovel" and in some it does not, but the average will be very nearly the time for a round trip.

There are no important grades on this work, the whole area having previously been leveled by steam shovel. At dump No. 1 it was necessary to break the train, leaving half the cars at the switch, but this was the only place at which any difficulty was experienced.

Under "Observations" it will be noted that the average time for one move and to move forward one foot are twice as great on the second day as on the first. This is doubtless due to the fact that the machine was moved further on each move on the first day and that the moves were so frequent that the men moved more

rapidly, and that there was also less clearing of the tracks, so that more pitmen could stay in the pit. The effect of these frequent moves is shown in the number of cars for one shovel move. On the first day it was only 8.6 (average), while on the second day, with two blasts and the bank caving, it was frequently 49.5, or one move for about every five trains. The rate of transportation was about a mile in 16 minutes.

Fig. 12. View of Shovel at Work on the New Passenger Storage Yards of the Pennsylvania Railroad at Long Island City

Fig. 13

Fig. 14. Views of Shovel at Work on the New Passenger Storage Yards of the Pennsylvania Railroad at Long Island City

Fig. 15. Slide Blocking Dinkey Track

OBSERVATIONS

Weight	70 tons
Gauge	4′ 8½″
Height of lift	6′
Capacity of dipper	2.66 cu. yds., water measure
Kind of teeth	Manganese points
Height blocked up	20″
Capacity of cars, water measure	4.17 cubic yards
Capacity of cars, place measure	3.6 cubic yards
Number of cars in train	9 and 10
Height of cars above their track	6′
Length of haul, approximately	3500′
Length of runaround, approximately	9000′
Weight of dinkeys	18 tons
Style of car	Side dump on both sides
Gauge of track	Narrow
Number of trains	3

Average time for a round trip . 27.3 min. (11 observations)
Grades, level except slight ones near dumps; on one grade the train was broken
Time traveling to dump No. 1 . . 8 minutes. (See sketch)
Time traveling to dump No. 2 . . . . 6 minutes
Time traveling to dump No. 3 . . . . 13 minutes
Time to dump cars No 1, broke train, 14 minutes for nine cars
Time to dump cars No. 2 . . . . . . 6 minutes for ten cars
Time to dump cars No. 3 . . . . . . 3 minutes for ten cars
Time traveling from dump to shovel No. 1 . . . 8 minutes
Time traveling from dump to shovel No. 2 . . . 8 minutes
Weather, clear

	First Day	Second Day
Number of cars loaded . . .	190	396
Average time to load one car .	50 sec.	39 sec.
Cubic yards excavated . . .	684	1426
Total distance moved forward during day	130′	51′
Number of times moved forward	22	8
Total time moving forward .	158½ min.	107 min.
Average time for one move . .	7.2 min.	13.4 min.
Average time to move forward one foot	1.2 min.	2.1 min.
Maximum distance moved forward in one move	8′ 3″	8′
Average distance moved forward each time	5′ 11″	6′ 4½″
Swings per minute	3.7 (1)	3.7 (1)
Average time for one swing . .	16.3 sec.	16.3 sec.
Time to load 1 cubic foot with dipper	.52 sec.	.40 sec.
Minutes per working day, less times for accidental delays .	540½ min.	574½ min.
Area of section	87½ s. f. (a. m.) 500 s. f. (p. m.)	500 s. f.
Height of face	3½′ (a. m.) 25′ (p. m.)	25′
Number times blasted bank . .	None	2
Coal used	2.16 short tons, at 42 lbs. per cu. ft.	2.7

	First Day	Second Day
Pounds of coal per cubic yard excavated	6.32 (3)	3.8
Total cost to excavate, transport and spread one cubic yard .	16.1 cents (2)	10.81 cents
Number of cars for one shovel move	8.64	49.5
Average time between beginning of one shovel move and beginning of next	16.94 min.	80.3 min.

(1) The two days were averaged, 57 observations taken at different times.

(2) Does not include cost of moving back. This should be charged to amount taken out before the next move back is made.

(3) No deductions made for moving back.

TIME STUDY

First Day	Forenoon	Afternoon
Started work	6:58	12:49
Stopped work	11:58	5:42½

Total time worked 300 Min. + 293½ Min. = 593½ Min. = 9 hours 53½ minutes.

	Minutes	Seconds	Per Cent
Actual working	157	15	26.5
Spotting cars	. .	30	0.1
Waiting for cars	38	30	6.5
Moving shovel (158½ minutes forward, 106 minutes back .	264	30	44.5
Idle, repairing boom	53	. .	8.9
Miscellaneous delays			
Loosening bank	5	. .	0.8
Clearing track	11	. .	1.9
Handling boulders	15	15	2.6
Setting up, shifting track, etc., after moving back	48	30	8.2
Total time under observation .	593	30	100.0

Direct Labor Distribution per Day	Standard Basis—First Day						
	Prep. Charge	Loading	Transporting	Dumping	Breaking	Incidental	Total
Runner	...	$5 00	...	...	..	...	...
Craneman	...	3.60	...	...	..	...	...
Fireman	...	2.40	...	...	..	...	...
1 pitman	...	1.75	...	...	..	...	...
7 pitmen	...	10.50	...	...	..	...	...
1 coalman	...	1.50	...	...	..	...	...
3 locomotive engineers	...	...	$7.80	...	..	...	...
3 locomotive brakemen	...	...	4.50	...	..	...	...
Switchman	...	...	1.50	...	..	...	...
2 drillers, ½ day	...	...	...	...	$1.50	...	...
16 laborers, moving back	$24.00	...	...	...	..	...	...
1 foreman, moving back	2.00	...	...	...	..	...	...
29 laborers, moving back, ½ day	21.75	...	...	...	..	...	...
2 foremen, moving back, ½ day	2.00	...	...	...	..	...	...
35 laborers, on 3 dumps, ½ day	...	...	...	$26.25	..	...	...
3 foremen, on 3 dumps, ½ day	...	...	...	3.00	..	...	...
1 superintendent	...	...	...	...	..	$6.00	...
*4 blacksmiths' helpers	...	...	...	...	..	10.00	...
*1 foreman blacksmith	...	...	...	...	..	3.50	...
Total cost of labor per day	$49.75	$24.75	$13.80	$29.25	$1.50	$19.50	$138.55
Cost direct labor per cubic yard, cents	7.27	3.62	2 02	4.28	0.22	2.85	20.26
Per cent	35.9	17.9	10.0	21.1	1.1	14.0	100.0

*This large blacksmith force was due to the extra work caused by overhauling machinery as contract neared completion.

Process Analysis. First Day	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard
	Min.	Sec.			
Charge to waiting for blasters	20	15	3.4	0.123	0.123
Charge to loading					
1. Actual loading	157	15	26.5	0.960	3.189
2. Delays					
a Moving up, 158½'; back, 106'	264	30	44.5	1.610	
b Repairs	53	..	8.9	0.322	
c Miscellaneous	48	30	8.2	0.297	
Charge to transporting and dumping					
1. Waiting for cars	39	..	6.6	0.239	0.308
2 Miscellaneous	11	..	1.9	0.069	
	593	30	100.0	...	3.620

TIME STUDY

Second Day	Forenoon	Afternoon
Started work	7:00	12:40
Stopped work	11:48½	5:50

Total time worked 288½ Min. + 310 Min. = 598½ Min. = 9 hours 58½ minutes

	Minutes	Seconds	Per Cent
Actual working	259	30	43.4
Spotting cars	Negli	gible	0.0
Waiting for cars	122	00	20.4
Moving shovel	107	00	17.9
Idle time—Rain	7	00	1.2
Repairing boom	17	00	2.8
Clearing track after blast	36	30	6.1
Misc. time—Clearing bank	14	00	2.3
Blasting	2	30	0.4
Moving boulders	18	00	3.0
Boulder on track	9	00	1.5
Loosening bank	4	00	0.7
Jacking up	2	00	0.3
Total time under observation	598	30	100.0

Direct Labor Distribution per Day	Standard Basis—Second Day					
	Loading	Transporting	Dumping	Breaking	Incidental	Total
Runner	$5.00	...	...	...	...	...
Craneman	3.60	...	...	...	...	...
Fireman	2.40	...	...	...	...	...
1 pitman	1.75	...	...	...	...	...
8 pitmen	12.00	...	...	...	...	...
1 coalman	1.50	...	...	...	...	...
3 locomotive engineers	...	$7.80	...	...	...	...
3 locomotive brakemen	...	4.50	...	...	...	...
1 switchman	...	1.50	...	...	...	...
4 laborers, blasting	...	...	...	$6.00	...	...
1 foreman, blasting	...	...	...	2.00	...	...
35 laborers, 3 dumps	...	...	$52.50	...	...	...
3 foremen, 3 dumps	...	...	6.00	...	...	...
1 superintendent	...	...	...	...	$6.00	...
Total cost of labor per day	$26.25	$13.80	$58.50	$8.00	$6.00	$112.55
Cost of labor per cubic yard, cents	1.84	0.97	4.10	0.56	0.42	7.89
Per cent	23.3	12.3	52.0	7.1	5.3	100.0

Process Analysis Second Day	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard
	Min.	Sec.			
Charge to waiting for blasters	38	..	6.4	0.118	0.118
Charge to loading					
1. Actual loading	259	30	43.3	0.796	
2. Delays					
a Moving up	107	..	17.9	0.329	1.205
b Repairs	17	..	2.8	0.052	
c Miscellaneous	9	..	1.5	0.028	
Charge to transporting and dumping					
1. Waiting for cars	122	30	20.5	0.377	0.517
2. Miscellaneous	45	30	7.6	0.140	
Total	598	30	100.0		1.840

From the record which follows:

Average cubic yards excavated per day during 1908	1705

$$\frac{\text{Average cost direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$24.75}{1705} = 1.45 \text{ cts. per cu. yd.}$$

Process Analysis Second Day's Observation as Basis	Time		Per Cent	Cost per Yard in Cents	Total Cost per Yard Cents
	Min.	Sec.			
Charge to waiting for blasters	38	.	6.4	0.093	0.093
Charge to loading					
1. Actual loading . .	259	30	43.3	0.628	
2. Delays					
a Moving up . .	107	. .	17.9	0.259	0.950
b Repairs . . .	17	. .	2.8	0.041	
c Miscellaneous .	9	. .	1.5	0.022	
Charge to transporting and dumping					
1. Waiting for cars.	122	30	20.5	0.297	0.407
2. Miscellaneous . .	45	30	7.6	0.110	
Total	598	30	100.0		1.450

It is our understanding that the following represents the output in cubic yards for the year 1908:

Day	Actual Number Hours Employed	January	Actual Number Hours Employed	February	Actual Number Hours Employed	March	Actual Number Hours Employed	April	Actual Number Hours Employed	May	Actual Number Hours Employed	June
1	9	2164	..	...	Sun.		10	2765	9½	2060	..	...
2	4	1051	..	...	9	2419	10	2765	6	1224	3	587
3	8	1543	7	1490	9	2297	9¼	2549	Sun.		9¼	1721
4	5	547	8	1872	8½	1678	10	2895	10	1440	10	2052
5	Sun.		8	1699	4	771	Sun.		5½	1138	10	1800
6	9	1591	7	1476	..	...	10	2794	9	1685	10	1483
7	5	1080	8	1843	10	1469	9	2462	rain		Sun.	
8	6	1455	7½	1728	Sun.		4¼	1210	9½	1930	10	2268
9	8	2031	Sun.		rain		10	2704	10	1908	2	216
10	8	2160	7	1498	9	2189	8½	1224	Sun.		10	1462
11	9	2160	7	1570	10	2880	rain	86	10	2092	10	2203
12	Sun.		7½	1451	9¼	2808	Sun.		9½	2333	10	2020
13	6	1570	8	1804	8¾	2462	10	2048	10	2394	10	1894
14	9	2171	7	1440	10	2776	10	2290	7¼	1732	Sun.	
15	9	2534	3	414	Sun.		9	2160	5	1199	8	1422
16	5	1354	Sun.		9½	2862	7½	1836	10	2167	6	1181
17	8	2354	4	558	5	1191	9½	2520	Sun.		10	1976
18	9	2448	9	1703	..	...	10	2491	9	2034	8	1469
19	Sun.		snow rain		rain		Sun.		10	2114	10	1829
20	9	391	9	2203	..	...	10	2444	9	2106	10	1728
21	8	1868	9	2232	9	2056	9	2524	10	1987	Sun.	
22	3	371	8½	2153	Sun.		7½	1980	4	770	10	1800
23	8	1080	Sun.		8	2016	9	2419	10	1915	8	1609
24	snow		9	2023	10	2794	7½	1987	Sun.		10	1584
25	7	986	9	2160	10	3000	7	1930	9½	2028	9	1663
26	Sun.		2	461	10	1836	Sun.		10	2005	10	1714
27	8	1548	7½	1854	10	241	8½	1552	10	2081	9½	1512
28	6	1591	5½	1195	10	1814	3	900	10	2038	Sun	
29	8	2002	6	1620	Sun.		10	2318	10	1908	10	1422
30	9	2034	..	...	9¼	2635	7	1213	3	173	10	1584
31	7	1714	..	...	9	2419	..	...	Sun		..	...
Total . .		41798		36447		44613		54066		44461		40199

Day	Actual No. Hrs. Employed	July	Actual No. Hrs. Employed	August	Actual No. Hrs. Employed	September	Actual No Hrs. Employed	October	Actual No. Hrs. Employed	November	Actual No. Hrs Employed	December
1	10	1512	9½	1591					Sun.		8¾	1379
2	1½	205	Sun.						7¾	1351	9½	1173
3	10	1392					9¼	1246	2½	674	8	1114
4	Holiday						Sun.		7	1519	7¾	1322
5	Sun.						7½	1250	6	1337	8	1278
6	10	1739			Sun.		8	1323	6½	1029	Sun.	
7	9½	1526					8¾	2870	7	1365		
8	8	1426					6.43	1533	Sun.		7½	1278
9	9¼	1685	Sun.				7	1287	4½	952	8¼	1728
10	10	1685					6.4	1837	8½	1148	6¾	1728
11	8¾	1743					Sun.		7¼	1239	8¾	1872
12	Sun.						6	1354	6½	1197	7½	1683
13	10	2145			Sun.		7¼	1862	5¼	1015	Sun.	
14	7¾	1692					7	1124	6½	1204	7½	1944
15	10	2149					7¼	1701	Sun.		8¼	2322
16	10	2162	Sun.				8¼	1708	6	1029	6¼	1683
17	8	1940					8	1704	6	1169	6¾	1683
18	10	2315					Sun.		6¾	1386	2½	711
19	Sun.						7½	1694	3½	891	8¼	2133
20	9¼	1937			Sun.		7½	1460	6	1434	Sun.	
21	10	2189					7½	1641	5	1365	8½	2133
22	9	1696					7½	1505	Sun.		7½	1944
23	8¾	1825	Sun.				7¼	1537	5½	1614	6½	1422
24	8¼	1692								1885	7	1683
25	4¼	709					8.10	1407	6.40	1851		
26	Sun.						9	1659	6¼	1620		
27	8	1623					7.20	1235	7.05	1881		
28	8	1537					6½	1393	6.0	1590	7	2088
29	8¼	1714					8	1680			8	2088
30	10	1811	Sun.				7½	1687		1150	8	1827
31	7½	1260					5¾	840			8¾	2349
Total . .		43309						38537		32895		40565

Month	Total Days Worked	Total Days in Month	Number of Stormy Days	No. of Days could have Worked Sun. Holiday inc.	Actual No. Days Worked less all Delays
*January .	26	31	1	26	21.10
*February .	23	29	1	25	18.17
March . .	21	31	3	23	18.73
April . .	25	30	1	25	20.65
May . . .	25	31	1	25	21.58
June . . .	25	30	0	26	23.28
July . . .	26	31	0	27	22.38
August . .	1	31		26	
September .	0	30	0	26	
October . .	25	31	0	27	18.64
November .	25	30	0	25	13.92
*December	24	31	0	27	17.35
Total . .	246	366	7	308	195.80

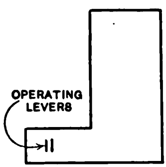
*9-hour days during January, February and December

REPORT No. 9 — SHOVEL No. 1121

INSPECTED SEPTEMBER 4 AND 7, 1909

CHICAGO, ILL.

SHOVEL This is a 70 C shovel located near Western Avenue and Thirty-fifth Street, Chicago, Ill., owned by John W. Farley, and employed in digging a sewer trench. It is new and of the latest design. Its distinguishing features are the location of the operating levers, those being placed about five feet outside the shovel housing, as shown in the sketch; the long dipper handle; and the support upon which the shovel rests. The operating levers are placed outside of the shovel house, in order that the operator may have an unobstructed view of the bottom of the trench. The dipper handle is 54 feet long, so that it can reach into the deep trench, which was 26x16 feet. Both it and the boom are made of wood and are steel plated. The supporting structure consists of the truss arrangement shown in the Bucyrus catalog. The shovel is taken off its trucks and placed on this structure, rollers being used to move it backward and forward.

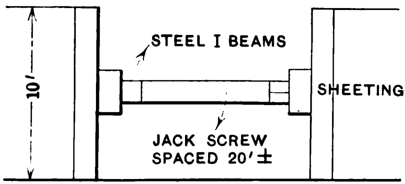


The shovel crew consisted of engineer, craneman, fireman and seven rollermen. There were also employed six trimmers, six bracers and one foreman following the digging.

To move the shovel backward or forward, a cable, hauled on by the main engines, was led out to a "dead man." By actual timing the shovel was moved back 416 feet in 3½ hours.

Two days were spent in observing this shovel. On the first day the top soil to a depth of 10 feet was

removed and on the second day the remaining depth of 26 feet was taken out. As the shovel excavates the trimmers follow it, trimming down the sides for the bracers who follow with the sheeting. Two I-beams about 50 feet long are placed as shown in the sketch, so that when the next bench is taken out and it is necessary to draw the braces the I-beams hold the sheeting and the shovel works between the jack screws. When the shovel moves forward the jack screws are slightly loosened and the I-beams are attached to the shovel and hauled forward with it, the wooden bracing being placed behind the I-beams. This being a new shovel there have been no repairs.



PLANT ARRANGEMENT The sketch shows the arrangement. Some cars were hauled out on the main line to a dump some distance away. Therefore both narrow and standard gauge tracks were necessary. On both days of the observation the dump was as indicated on the sketch, this being back-filling. Eighteen-ton dinkeys were used and standard gauge and narrow gauge cars of six and four-yard capacity respectively. The average time for a round trip on the first day was 19.8 minutes (28 observations), and on the second day was 16.8 minutes (22 observations).

The concrete mixer was on a platform similar to that upon which the shovel was placed. This follows behind the shovel.

COST KEEPING The contractor keeps accurate unit costs but does not give outside information, so that these could not be obtained.

OBSERVATIONS

Gauge	Standard
Capacity of dipper	2 yards water measure
Height of lift	35′ ± from bottom of trench to top of cars
Kind of teeth	Manganese steel
Length of boom	36′
Length of dipper handle	54′
Height of boom above pivot	12.4′
Horizontal reach of boom	30½′
Farthest dipper can reach to dump	50′
Diameter of bull wheel	8′
Distance inside dinkey track to pivot	24′
Depth of dipper (water measure)	42″
Depth of dipper including lip	60″
Depth of dipper including teeth	70″
Number of cars loaded	126 (48, 6-yard; 78, 4-yard)
Cubic yards excavated (place measure)	569
Total distance moved forward during day	60′
Number of times moved forward	4
Maximum distance moved forward in one move	16′ 8″
Average time between beginning of one shovel move and beginning of next	142. 3 minutes.
Number of cars to one shovel move	31
Area of section	256 square feet
Height of face	16′

Weather, clear.

TIME STUDY

	Forenoon	Afternoon
Started work	7:00	12:57
Stopped work	12:00	5:59

Total time worked, 300 Min. + 302 Min. = 602 Min. = 10 hours 2 minutes.

	Minutes	Seconds	Per Cent
Actual working	270	30	44.9
Spotting cars	1	30	0.3
Waiting for cars	138	..	22.9
Moving shovel	135	..	22.4
Time idle			
Boulder in bucket	2	..	0.3
Waiting for men to dig out a little on sides	5	..	0.8
Repairing braces	2	..	0.3
Removing bracing	32	..	5.4
Miscellaneous delay, moving cross bracing	16	..	2.7
Total time under observation	602	..	100.0

Cost of Direct Labor (Loading)	Standard Basis Per Day
Runner	$5.00
Craneman	3.60
Fireman	2.40
7 rollermen	10.50
	$21.50

Cubic yards loaded on day of excavation, 569.

$$\frac{\text{Cost of labor per day}}{\text{Number cubic yards per day}}=\frac{\$21.50}{569}=3.78 \text{ cts. per cubic yard.}$$

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loosening and breaking	55*	..	9.2	0.348	0.348
Charge to loading					
1. Actual loading	270	30	44.9	1.698	2.555
2. Delays	..	..	...	...	
a Moving up	135	00	22.4	0.846	
b Miscellaneous	2	00	0.3	0.011	
Charge to transporting and Dumping					
1. Waiting for cars	139	30	23.2	0.877	0.877
	602	..	100.0	...	3.780

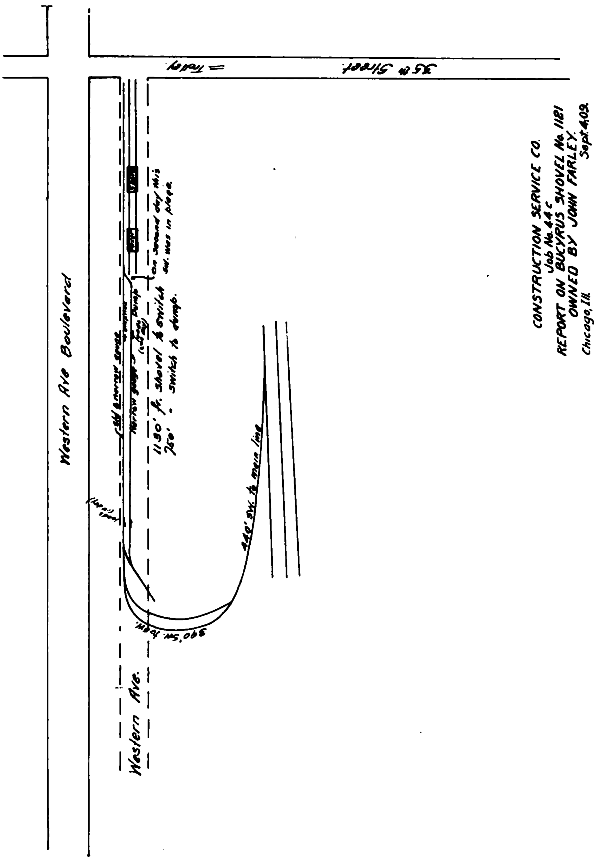
*Fifty minutes of this time was required for the braces. Repairing (2 minutes); to remove (32 minutes); and to arrange (16 minutes).

Dipper Performance		Minimum	Average	Maximum	Number Obs.	No. Attempts
Digging . . .	Time in Sec.	3½	9.7	18	15	15
Swinging loaded.		4¾	6.5	12	13	. .
Swinging empty .		3	7.9	11	10	. .
Falling empty .		4	5.1	7	9	. .
Time to fill and load one dipperful		15¼	29.2	48	. .	. .

Time for a complete swing

	Minimum	Average	Maximum	No. Obs.
Seconds	23½	28.9	35	9

Fig. 16. Shovel No. 1121



CONSTRUCTION SERVICE CO.
Job No. 44 C
REPORT ON BUCYRUS SHOVEL No. 1121
OWNED BY JOHN FARLEY.
Chicago, Ill.
Sept. 4 09.
35th Street
Trolley
Western Ave Boulevard
Western Ave.
1190' ft. shovel to switch
750' " switch to dump.
440' Sw. to main line
390' Sw. back
On second day this sw. was in place.

Figs. 17 and 18. Bucyrus Shovel on Western Avenue Sewer, Chicago, Ill.

CHAPTER VII

STEAM SHOVEL WORK IN CLAY

Clay is more susceptible to moisture than any of the other materials considered in this volume. It will stand with a nearly vertical face before excavation and can be dug very readily when fairly dry. When rather wet it is sticky and offers great resistance to the lifting motion of the bucket. With a powerful engine this is of no great disadvantage, since the resistance is smooth and does not rack the boom and shipper shaft. In the pit, however, the discomfort attendant upon working in this wet material is very considerable. To handle it wet with hand shovels is laborious, as it sticks to the bowl of the shovel and tries to take the shovel and the shoveler with it when cast. A hole or two punched in the bowl will often afford much relief to the men. This material containing practically no voids, is very heavy, and, owing to its stiffness, a large amount in comparison with sand or gravel can be loaded upon a car. Ton for ton, it is economical to transport for this reason. In wet weather it is apt to cling like flypaper to the car and delay the dumping operation. When handled with a toothed dipper it is liable to get between the teeth in chunks and cling to them when dumping into the car, so that only a portion of the dipper load is released for each swing. This is very irritating to the men and expensive to the management.

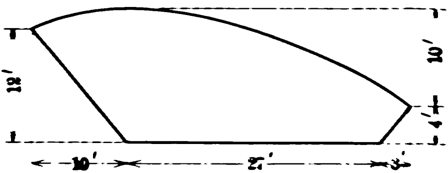
REPORT No. 11 — SHOVEL No. 1119

INSPECTED JULY 15, 1909
KENT, OHIO

GENERAL CONDITIONS This shovel was working less than a mile from No. 1118,* on the same contract, with, however, some

*See page 49.

difference in the nature of the material handled. The same general methods were in use by Mr. Hengst and the same general efficiency was observable.



Typical Cross Section

OBSERVATIONS

Material—Clay mixed with sand with occasional sand pockets. When dry could be handled easily but when wet it was very gummy and stuck in dipper badly. Some quick sand.

Type of shovel	70 C Bucyrus
Distance of move	6'
Kind of teeth	Rock
Height of lift	8'
Size of ties under shovel	6" x 8" x 8'
Size of bucket	2½ yards
Age of shovel	2 months
Duration of job	4½ months
Length of shift	10 hours
Number of shifts per day	1

Coal is handled by team; water piped direct to shovel.

Repairs are made on shovel as needed and at night. Extra repair parts kept in stock for emergency. Made by crew and boilermaker.

Coal used	3 tons in 10 hours
Water used	3500 gallons in 10 hours

Boiler is cleaned once a month.

Cost of repairs	Repairs made on job

OBSERVATIONS—*Continued*

Contract price . . . . 25c. per yard in embankment (which includes embankment)
Narrow gauge 3' track, 55-pound rail.
Kind and size of cars used . . . . K. & J., 4-yard
Dinkey braked by steam; cars by hand.
Hand signals used; brakeman standing on shovel.
Kind and size of dinkey . . . . Vulcan, 16-ton
Length of haul . . . . Max. 2700', min. 2000'
Number of trains . . . . 2—12 cars
Age of cars and dinkey . . . . 4½ months
Weather, fair

Cars figure 4¼ yards each according to this record and monthly estimate for first three months.

This shovel cut into right of way for several days and was then turned into borrow pit. The preparatory cost of cutting into right of way was $400 and to cut into borrow pit $1200 more. Shovel was delayed from May 19th to May 26th, on account of right of way difficulties. Total preparatory costs and cost of delay were said to be $3000.

In general, remarks on No. 1118 will apply to No. 1119, as they are managed in exactly the same way.

TIME STUDY

	Forenoon	Afternoon
Started work	10:25	11:57:00
Stopped work	11:27:45	4:56:30

Total time worked 62¾ + 299½ = 362¼ minutes = 6 hours 2¼ minutes.

	Minutes	Seconds	Per Cent
Actual working	229	42	63.4
Spotting cars	...	..	...
Waiting for cars	69	20	19.1
Moving shovel	49	18	13.6
Miscellaneous delays . . .	13	55	3.9
Total time under observation .	362	15	100.0

From the records which follow:

Number of carloads excavated per day (average of 36 days) 380 @ 4¼ yards.

Cubic yards loaded per day (average of 36 days) 380 x 4.25 x .90* = 1450 cubic yards.

*0.90 = ratio of $\frac{\text{Place measure}}{\text{Water measure}}$

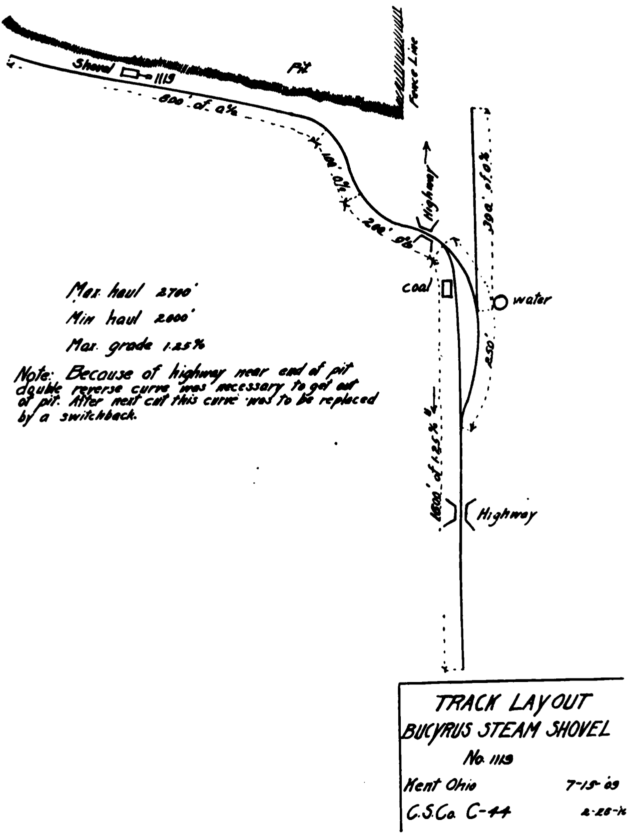
Direct Labor Distribution Per Day	Standard Basis				
	Loading	Transporting	Dumping	Incidental	Total
Runner	$5 00	...	...	...	...
Craneman	3.60	...	...	...	...
Fireman	2.40	...	...	...	...
4 pitmen	6.00	...	...	...	...
Dump foreman	...	...	2.00	...	...
7 dumpmen	...	...	10.50	...	...
2 brakemen	...	3.00	...	...	...
2 dinkeymen	...	5.20	...	...	...
1 pipeman	...	...	...	1.50	...
1 watchman	...	...	...	1.50	...
Total cost of direct labor per day	$17.00	$8.20	$12.50	$3.00	$40.70
Cost per day per cubic yard (cts)	1.17	0.57	0.86	0.21	2.81
Per cent	41.6	20.3	30.6	7.5	100.0

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to loading					
1. Actual loading	229	42	63.4	0.742	
2. Delays					
a Moving up	49	18	13.6	0.159	0.946
b Miscellaneous	13	55	3.9	0.045	
Charge to transporting and dumping					
1. Waiting for cars	69	20	19.1	0.224	0.224
	362	15	100.0	...	1.170

Time Study Deductions	Number of Obser-vations	Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	16	2	15	3	5	4	25
Time between moves, shovel working . .	16	10	10	13	29	15	25
Time between trains, idle	16	3	30	4	20	5	15
Time per dipper . .	14	..	19	..	21	..	23
Number of dippers per move . . .	16	26		36		42	
Number of dippers per train	23	25		27		30	
Number of dippers per car	230	..		2¼		..	

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}}=\frac{29{,}160}{6{,}000}=4.86$$


Shovel
1119
600' of 0%
Pit
Fence Line
100' 0%
Highway
200' 0%
300' of 0%
coal
water
250'
1800' of 1.25%
Highway
Max. haul 2700'
Min haul 2000'
Max. grade 1.25%
Note: Because of highway near end of pit double reverse curve was necessary to get out of pit. After next cut this curve was to be replaced by a switchback.
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No. 1119
Kent Ohio
7-15-09
C.S.Co. C-44

Figs 19 and 20. Bucyrus Shovel Loading Clay and Sand on W. and L. E. R. R. Kent, Ohio

REPORT No. 12 — SHOVEL No. 843

INSPECTED JULY 10, 1909
CLEVELAND, OHIO

LOCATION Shovel No. 843 was working during July on a deep cut on the L. S. & M. S. cut-off south of Cleveland, Ohio, where the line runs through Brooklyn.

GENERAL CONDITIONS The finished cut is to be for a four-track line and the bench on which the shovel was working at the time was within 3 feet of finished sub-grade. On the south side of the cut the excavation was to grade and one cut more was needed on the middle bench to finish the work. The remaining 3 feet to the sub-grade, on the north side was to be taken out by hand. A complete cross section at the time of observation is given in the illustration.

The shovel was to go through the cut once more on the center line, or a little to the left of it, so as to take the 7-foot heading to grade, and as much of the 3-foot cut on the north side as possible.

CREW The entire shovel force consisted of the shovel engineer, craneman and fireman, six pitmen, and one coal passer. Transportation force consisted of three crews of three men each. There were no extra men engaged in any capacity about the shovel, no pipe men, extra pitmen to look after drainage, drillers or blasters.

MATERIAL The material was dry clay and disintegrated shale. When the dipper was run into the bank the material broke up into fine flake spalls almost like small shells, and as it was perfectly dry it could be handled with the utmost ease. When

the shovel was near the bank after moving up, the dipper could penetrate to half its depth by inertia alone before the crowding engine was started, thus insuring a full dipper at every swing even though it might be brought but half way up by the hoisting engine. The dipper was dumped easily and was completely emptied at each dumping. When an attempt was made to heap a car, material was almost sure to be lost, as it was so light and flaky and so lacked cohesion that it would run over the side. For the same reason the dipper had to be spotted very carefully before it was dumped.

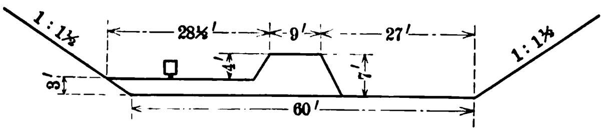
In spite of whatever care the shovel runner exercised in dumping his dipper and the brakeman in spotting his cars, the track had to be cleaned after each train pulled out. This, of course, was done by the pitmen, and often, when moving up occurred between trains, they were able to get the track clear and look after their regular duties as well.

MOVING UP When moving up the shovel, a 2-inch pipe was used to swing the jack blocks clear of the ground instead of the ordinary wooden pole. This pipe was held in a bracket attached to the jack arm and had a collar about 4 inches from its end, which kept the chain that suspended the jack block from slipping along the pipe. This pipe was held by the bracket and was always in place, there being little danger of its breaking or splitting, as is often the case with wooden poles.

SUPPLIES All supplies were brought to the shovel by dump trains. Water was carried in the tender (the dump engines were standard railroad locomotives) and a 4-inch rubber hose was run from the tender to the water tank of the shovel and the water siphoned over. This always caused some slight delay with every second or third train. Coal was shoveled

by hand to the pit behind the shovel. Thence it was carried in bushel baskets by a laborer who had rigged a gang plank with cleats at the back of the shovel. He dumped the coal on the extension platform back of the boiler.

TRANSPORTATION The average haul was about three miles over very rough track. Three standard railroad locomotives were used. The cars were the most modern type of Western "air dumps" of 12 yards capacity. They were built in two sizes, there being 40 cars with bodies 18 feet 9 inches long and five cars with bodies 26 feet in length. All were double truck, two-side dumps with wooden bodies. Trains were composed of 15 cars each. Ten men worked on the dump. The material was unloaded on one side over a bank about 40 feet high. When the track was not near the edge of the bank a spreader was used. This consisted of a steel scraper plate with one end hinged on the trucks of a flat car and the outer end supported by a line from a block on the floor of the car. The spread and depth of cut could be regulated by one man on the car, but often the operator of the spreader was helped by the brakeman of the train. The regular dump train engine was used in operating the spreader.



Typical Cross Section

OBSERVATIONS

Shovel	70-ton Bucyrus
Distance of move	6′
Kind of teeth	Standard earth
Height of cars above rail,	7′ and 7′ 6″
Shovel track to load track	4′
Size of ties under shovel	6″ x 8″ x 8′
Size of bucket	2½ yards
Age of shovel	3 years

Duration of job to date, 3 years 2 months; to be finished in 6 weeks from July 10, 1909.

Length of shift	10 hours
Number of shifts per day	1

Repairs are made on shovel as needed.

Coal used	2½ to 2¾ tons per day
Water used	6000 gallons per day

Boiler cleaned every two weeks.
Standard gauge track; 55-pound rails.
Train is braked by air.
Hand signals used; brakeman on top of loaded car.

Kind and size of dinkey	Standard locomotive
Length of haul	Said to be 3 miles
Number of trains	3 of 15 cars each

Weather, fair, very warm

Note.—The bank was dry and the pit seemed to need no draining. Material was easy to handle, and a much larger dipper could have been used. Four-yard cars had been employed previous to the 12-yard cars and it was found that two swings of a 2½-yard dipper filled these cars completely; seven swings of a 2½-yard dipper filled the 12-yard cars completely Pit crew was composed of rather green men. The runner said he could move up in 1 or 1½ minutes in such a pit with a good crew.

TIME STUDY

	Forenoon	Afternoon
Started work	9:25:30	12:30:15
Stopped work	11:35:00	4:57:25

	Min.	Sec.		Min.	Sec.		
Total time worked	129	30	+	267	10	=	6 hours

36 minutes 40 seconds.

	Minutes	Seconds	Per Cent
Actual working	228	5	57.5
Spotting cars	..	..	..
Changing trains	36	..	9.1
Moving shovel	112	20	28.3
Shovel taking water	8	50	2.2
Miscellaneous delays . . .	11	25	2.9
Total time under observation .	396	40	100.0

Cost of Direct Labor (Loading) Per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
1 coal passer	1.50
	$21.50

Number of carloads excavated on day of observation . . 90

Cubic yards loaded on day of observation, 90 x 12 x 0.83 = 900

Based on the performance observed the cubic yards loaded per 10-hour day $= \frac{900 \times 600 \text{ minutes}}{396\frac{2}{3} \text{ minutes}} = 1360$ cubic yards.

$$\frac{\text{Cost of labor per day}}{\text{Number of cubic yards per day}} = \frac{21.50}{1360} = 1.58\text{c. per cubic yard.}$$

Process Analysis	Time		Per Cent	Cost per Cubic Yard in Cents	Total Cost per Yard
	Min.	Sec.			
Charge to loading					
1. Actual loading .	228	5	57.5	0.908	1.436
2. Delays .					
a Moving up .	112	20	28.3	0.447	
b Miscellaneous	20	15	5.1	0.081	
Charge to transportation and dumping					
1. Waiting for cars .	36	..	9.1	0.144	0.144
	396	40	100.0	. . .	1.580

Time Study Deductions	Number of Observations	Minimum		Average		Maximum	
		Min	Sec.	Min	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	31	2	10	2	51	3	50
Time between moves, shovel working .	37	3	20	6	16	13	55
Time between trains .	6	2	..	6	..	9	30
Time per train loading	6	.	..	38	01	..	..
Time per dipper . .	26	.	14.2	..	17.9	..	22.2
Number of dippers to move	31	12		18.7		23	
Number of dippers to train	6	..		114.5		..	
Number of dippers to car	90	..		7.6		..	
Number of trains loaded	..	..		6.		..	
Number of cars loaded	..	..		90.		..	
Cars per train . . .	..	..		15.		..	

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{50{,}000}{5{,}000 \text{ to } 5{,}500} = 10.0\text{–}9.1$$

Fig. 21. Bucyrus Shovel at Work in Deep Cut on the L. S. and M. S. R. R. South of Cleveland

Fig. 22. View of Spreader Used for Pushing Material over Bank

REPORT No. 13 — SHOVEL No. 666

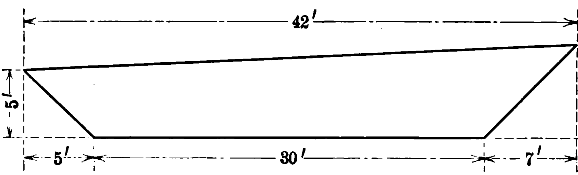
INSPECTED JULY 17, 1909

KENT, OHIO

LOCATION This work is part of that undertaken for correction of line on the W. & L. E. R. R. near Kent, Ohio, J. R. Dewitt, Manager.

GENERAL CONDITIONS The shovel had been working only three days and on the day of inspection was still cutting in. The cut was a "through," and for the purpose of getting material for a large fill on the job. At this point the ground had been wooded and because of old stumps, tree roots, etc., digging was rather slow. The inexperience of the pitmen also caused some delays.

MOVING SHOVEL Before cutting in, this shovel was moved 1600 feet. The shovel crew, 16 men, foreman and 1 team were engaged in this work for 8 hours, at a total cost of $34.00 or 2.12 cents per foot moved.



Typical Cross Section

OBSERVATIONS

Material, clay and loam with many stumps.
Shovel . . . . 70-ton Bucyrus
Distance of move . . . . 6'
Kind of teeth . . . . Heavy earth

OBSERVATIONS—*Continued*

Height of lift, cars 6′ 0″; shovel track to loading track, 6′ 6″; total 12′ 6″.
Size of ties under shovel . . . . 6″ x 8″ x 8′ 0″
Size of bucket . . . . 2½ yards
Age of shovel . . . . 5 years
Duration of job . . . . . 60,000 yards to be excavated
Length of shift . . . . 10 hours
Number of shifts per day 1
Supplies are handled as follows: coal, by wagon; water, piped.
Repairs are made as needed.
Coal used . . . . 3½ tons per shift
Cost of repairs not known, but $4000 to $5000 should be spent, as condition is bad.
Contract price . . . . 40c. for excavation
Contract including excavation.
Three working days; no rainy days since starting.
Track, narrow gauge, 36″, 30-pound.
Size of car used . . . . 4 yards
Car is braked by hand; dinkey by steam.
Hand signals used.
Kind and size of dinkey . . . . Vulcan, 16 tons
Length of haul . . . . 1000′ plus
Number of trains 2
Weather, fair, warm.

TIME STUDY

	Forenoon	Afternoon
Started work	9:00:35	12:30:00
Stopped work	10:47:35	5:04:22

	Min.		Min.	Sec.	
Total time worked	107	+	274	22	= 6 hours 21 minutes 22 seconds.

	Minutes	Seconds	Per Cent
Actual working	143	24	37.6
Waiting for cars	83	31	21.9
Moving shovel	97	57	25.7
Pulling track	51	45	13.6
Miscellaneous delays	4	45	1.2
Total time under observation .	381	22	100.0

Cost of Direct Labor (Loading) Per Day	Standard Basis
Runner working	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
	$20.00

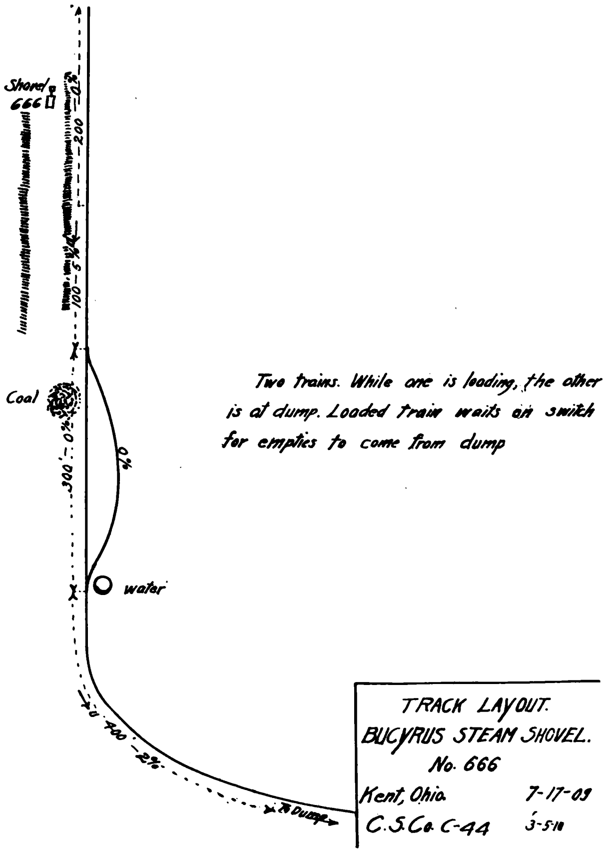
Number of cars loaded on day of observation . 189A 4 yards.
Cubic yards loaded on day of observation . 189 x 4 = 756.
Based on performance observed, the cubic yards loaded per 10-hour day $= 756 \times \dfrac{600 \text{ min.}}{381' \ 22''} = 1190.$

$$\frac{\text{Cost of labor per day}}{\text{Number of cubic yards per day}} = \frac{\$20.00}{1190} = 1.68\text{c. per cubic yard.}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost Cents
Charge to loading					
1. Actual loading	143	24	37.6	0.632	1.084
2. Delays					
a Moving up	97	57	25.7	0.432	
b Miscellaneous delays	4	45	1.2	0.020	
Charge to transportation and dumping					
1. Waiting for cars	83	31	21.9	0.368	0.596
2. Miscellaneous delays	51	45	13.6	0.228	
	381	22	100.0	. . .	1.680

TIME STUDY DEDUCTIONS

	Number of Observations	Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	14	3	15	7	00	12	5
Time between moves, shovel working .	16	6	50	8	58	11	5
Time between trains .	19	2	10	4	24	6	45
Time per train, loading	27	4	5	5	19	8	55
Time per dipper . .	16	0	19.0	0	21.6	0	31.2
Number of dippers, per move . .	16	20		25		33	
Number of dippers, per train . . .	27	14		14.8		17	
Number of dippers, per car	..	..		2.11		..	
Number of trains loaded	..	...		27		..	
Number of cars loaded	..	...		189		..	
Cars per train . .	..	...		7		..	


Shovel 666
100 - 5%
200 - 0%
Coal
300' - 0%
0%
water
400 - 2%
To Dump
Two trains. While one is loading, the other is at dump. Loaded train waits on switch for empties to come from dump
TRACK LAYOUT.
BUCYRUS STEAM SHOVEL.
No. 666
Kent, Ohio. 7-17-09
C.S.Co. C-44 3-5-10

REPORT No. 14 — SHOVEL No. 1128

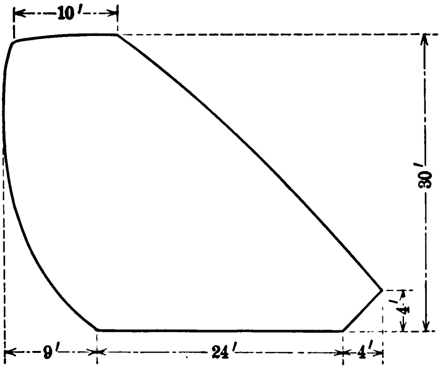
INSPECTED OCTOBER 4, 1909

BUHL, MINN. IN THE ORE REGION

LOCATION No. 1128 is a 95C Bucyrus shovel, owned by Butler Brothers, stripping contractors. At present it is engaged with No. 517 in stripping in the Grant mine (see p. 154).

GENERAL CONDITIONS The character of the stripping was such that no machine, however powerful, could handle all of it without some hesitation and straining. The cut was a side one and some 30 feet in height, of which the upper 17 feet were composed of a mixture of earth and clay containing just sufficient moisture to cause it to stick like molasses candy to the inside of the bucket, filling up the spaces between the teeth and decreasing their penetrative power, at the same time reducing the capacity of the dipper to such an extent that frequent stops had to be made to clean out the bucket. This was done by two of the pitmen equipped with small scraper and shovel. Such was the character of the upper part of the cut. This was very discouraging material to work in, but caused no straining on the part of the shovel. The lower part of the cut was a nearly solid mass of boulders, which were imbedded in the clay. Being round in shape, they offered scant grip for the teeth of the dipper, which would slide over them and bury itself in the softer material above. As might be expected, this strain on the shovel was severe. Frequently nests of large boulders were encountered, which were picked up and tossed to one side to be later broken with powder. In such material the teeth had to be replaced weekly and sometimes semi-weekly.

SHOVEL This shovel was equipped with tandem hoisting sheaves. The jacks could be swung inward, and the screws were operated, one by a wheel and the other by a bar passed through a hole in the top of the screw. In the afternoon the large pin that fastens the upper portion of the dipper to its handle failed as a result of the hard usage due to the boulders. Four men and the runner replaced it in 11 minutes and 15 seconds.



Typical Cross Section

OBSERVATIONS

Distance of move	5½'
Kind of teeth	Rock
Size of ties	6" x 7"
Height of lift	11' 3"
Size of bucket	3 yards
Age of shovel	New May, 1909
Length of shift	10 hours
Number of shifts, per day	2

Coal is dumped from one of the dump cars and then carried onto the shovel by a workman.

OBSERVATIONS—*Continued*

Water is supplied from a tank on a low hill near by.
Repairs are made by the day crew on Sunday, who get no extra money.
Coal used . . . . 2½ and 3 tons in 10 hours

Oil used . . . . $\begin{cases} \text{Black, 5 gallons in 24 hours} \\ \text{Cylinder, 5 gallons in 24 hours} \\ \text{Kerosene, 2½ gallons a night} \\ \text{Gasolene, 20 gallons a night} \end{cases}$

Lighting is furnished at night by four gasolene torches, each holding 2½ gallons, and by eight kerosene oil burners or torches.
Water used . . . . 12,800 gallons in 24 hours
Boiler is cleaned every second Sunday.
Standard gauge track; 55-pound rails.
Russell Wheel and Foundry 7-yard dump car used; water measure.
Engine braked by air.
Hand signals used.
Kind and size of dinkey . . . Baldwin locomotives, 50-ton ±
Length of haul . . . . about ½-mile
Number of trains 2
The locomotive new July, 1909.
Shovel has been on the present work since coming out of shop. New May, 1909. Moved forward 33 feet during day.
Height of car above rail . . . . 7′ 3″
Slope is slightly under cut and overhanging at top. Side cut.
Teeth have to be replaced once a week and sometimes more often.
Extra small parts such as bolts and nuts are kept on the shovel.
Larger duplicate parts are kept on hand at the Butler Bros. shops about 9 miles away.
Shovel was working down hill but cut was dry.
The track layout for this shovel and No. 517 will be given together under No. 517 (p. 154).
Weather, clear and cool.

TIME STUDY

	Forenoon	Afternoon
Started work	6:56:00	12:53:45
Stopped work	12:01:00	5:56:25

	Min.	Min. Sec.	
Total time worked	305 +	302 40	= 10 hours 7 minutes 40 seconds.

		Minutes	Seconds	Per Cent
Actual working		367	35	60.4
Waiting for cars		103	45	17.1
Moving shovel		49	40	8.2
Miscellaneous delays				
Oiling	1 man	1	45	0.3
Clearing bucket	2 men	6	20	1.0
Clearing bucket	2 men	5	40	0.9
Clearing bucket	2 men	4	35	0.8
Replacing heel pin	5 men	21	15	3.5
Rock between teeth	1 man	1	25	0.2
Car off track	6 men	8	00	1.3
Rock in teeth	1 man	0	30	0.1
Clearing bucket	2 men	2	55	0.5
Stone on track		0	45	0.1
Rock in teeth		1	0	0.2
Clearing bucket	2 men	4	0	0.7
Oiling	2 men	2	40	0.4
Clearing dipper	2 men	4	40	0.8
Rock on track	3 men	1	40	0.3
Chaining stone	3 men	3	45	0.6
Replacing bolt in stick	5 men	11	15	1.9
Clearing bucket	2 men	4	30	0.7
Total time under observation		607	40	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3 60
Fireman	2.40
4 pitmen	6.00
1 track cleaner	1.50
1 coal carrier	1.50
	$20.00

Number of carloads excavated on day of observation, 189 of capacity 7-yards (water measure).

Cubic yards loaded = 189 x 7 x 0.75* = 990.

Cost per day per cubic yard $= \frac{\$20.00}{990} =$ 2.02c. per cubic yard.

* 0 75 = ratio of $\frac{\text{Place measure}}{\text{Water measure}}$

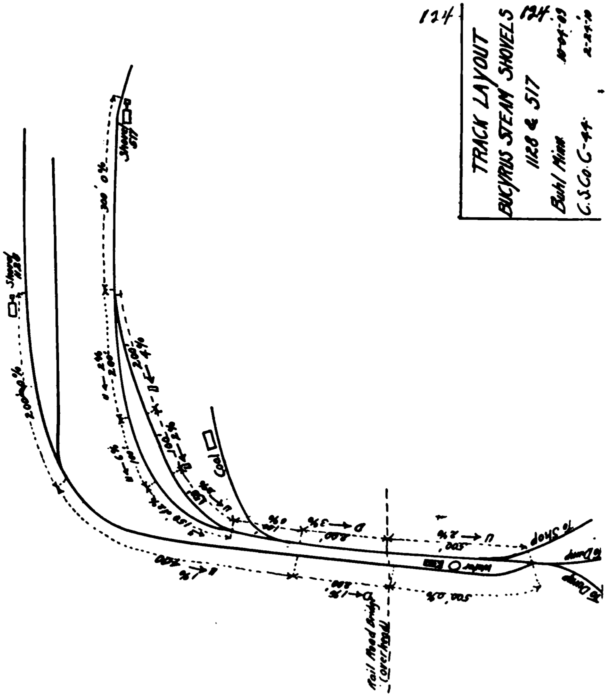
Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost Cents
Charge to loading					
1. Actual loading	367	35	60.4	1.220	
2. Delays					
a Moving up	49	40	8.2	0.166	1.641
b Repairs	32	30	5.4	0.109	
c Miscellaneous	43	45	7.2	0.146	
Charge to transporting and dumping					
1. Waiting for cars	103	45	17.1	0.345	0.379
2. Miscellaneous	10	25	1.7	0.034	
	607	40	100.0	. . .	2.020

TIME STUDY DEDUCTIONS

	Number of Observations	Minimum Min.	Minimum Sec.	Average Min.	Average Sec.	Maximun Min.	Maximun Sec.
Time of moving up, shovel idle	6	5	10	8	16.6	9	45
Time between moves, shovel working	5	56	15	64	55	82	15
Time between trains	16	3	55	6	22.5	12	05
Time per train, loading	18	13	10	20	25	28	35
Time per dipper	5	..	32.1	..	35.2	..	37.6
Number of dippers per move	5	90		112		153	
Number of dippers per train	18	30		35.5		43	
Number of dippers per car	189			3.38		..	
Number of trains loaded	..	18					
Number of cars loaded		189					
Cars per train	..	9 trains of 11 cars, and 9 trains of 10 cars each					

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{44{,}400}{5{,}000 \text{ to } 6{,}000} = 8\ 88 \text{ to } 7.40$$


TRACK LAYOUT
BUCYRUS STEAM SHOVELS
1128 & 517
Buhl Minn
C.S.Co. C-44
Shovel 1128
Shovel 517
Coal
Water
To Shop
To Dump
To Dump
Rail Road Bridge (overhead)

Figs. 23 and 24. Bucyrus Shovel Engaged in Stripping at Grant Mine, Buhl, Minn.

REPORT No. 15 — SHOVEL No. 650

INSPECTED AUGUST 30, 1909

CHICAGO, ILL.

THE SHOVEL This is a 70-ton shovel, owned by the Illinois Improvement Company, located at South Deering, Ill., and employed in digging slag. Its only distinguishing feature is the kind of teeth which are of special form.

SUPPLIES Water was taken from the tank of the locomotive and was paid for at the rate of 50 cents a tank. The engineer said that 1100 gallons were consumed in loading 21 cars, which is at the rate of about 2½ cents per car of 31 cubic yards, place measure, or at about eight cents per 100 cubic yards.

MATERIAL The digging was not difficult, being about the same as firmly cemented gravel. No blasting was necessary.

TRACK AND TRANSPORTATION Large freight cars and railroad engines were used and supplied by the railroad company, with the result that sometimes many cars were on hand and sometimes none.

The arrangement of the track is shown in the sketch, and the extent of the excavation, which was begun last May, by the photographs. On the day of our observation the shovel was idle 70 per cent of the time

OBSERVATIONS

Gauge	Standard
Capacity of dipper	2½ yards
Height of lift	10′
Kind of teeth	Special
Number of pitmen	4
Height blocked up	1′
Length of boom	28′
Length of dipper handle	18′ 6″
Height of boom above pivot	21′
Height of boom above shovel track	26′ 4″
Horizontal reach of boom	21′
Farthest dipper can reach to dump	27′
Highest dipper can reach to dump	16′
Diameter of swing circle	7′ 6″
Height of dinkey tracks above shovel tracks	2′
Distance inside dinkey track to inside shovel track	20′
Depth of dipper	48″
Depth of dipper, including lip	60″
Depth of dipper, including teeth	82″
Number of cars loaded	25
Cubic yards excavated	822
Total distance moved forward during day	36′
Number of times moved forward	6
Maximum distance moved forward in one move	6′ 4″
Average time between beginning of one shovel move and beginning of next	68.8 minutes
Number of cars to one shovel move	4.5
Time shovel is interrupted to change trains	362 minutes
Area of section	600 square feet
Height of face	Maximum 20′, minimum 2′
Water used	1100 gallons to load 21 cars
Weather, clear	

TIME STUDY

	Forenoon	Afternoon
Started work	7:00	12:30
Stopped work	12:00	5:30
Total time worked	300 + 300 min. = 600 min. = 10 hours	

	Minutes	Seconds	Per Cent
Actual working	156	00	26.0
Changing trains	362	00	60.4
Moving shovel	17	30	2.9
Idle—Taking water	8	30	1.4
Getting up steam	50	00	8.3
Miscellaneous delays			
Clearing track	6	00	1.0
Total time under observation	600	00	100.0

Direct Labor Distribution Per Day	Standard Basis		
	Loading	Incidental	Total
Runner	$5.00	...	...
Craneman	3.60	...	...
Fireman	2.40	...	...
4 pitmen	6.00	...	...
Watchman	...	$1.50	...
Total cost of labor per day	$17.00	$1.50	$18.50
Cost per day per cubic yard	2.07	0.18	2.25
Per cent	92.0	8.0	100.0

The above costs are based upon the day's output of 822 cubic yards.

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loading					
1. Actual loading	156	00	26.0	0.538	0.799
2. Delays					
a Moving up	17	30	2.9	0.060	
b Miscellaneous	58	30	9.7	0.201	
Charge to transporting and dumping					
1. Waiting for cars	362	00	60.4	1.248	1.271
2. Miscellaneous	6	00	1.0	0.023	
	600	..	100.0	...	2.070

Dipper Performance		Min.	Average	Max.	No. of Obs.	No. Attempts
Digging . . .	Time in seconds	3½	9.3	26	63	63
Swinging loaded		2½	5.1	20½	63	63
Swinging empty		2	3.7	7	63	..
Falling empty .		1½	3.8	12	63	..
Time to fill and load one dipperful		9½	21.9	65½	63	..

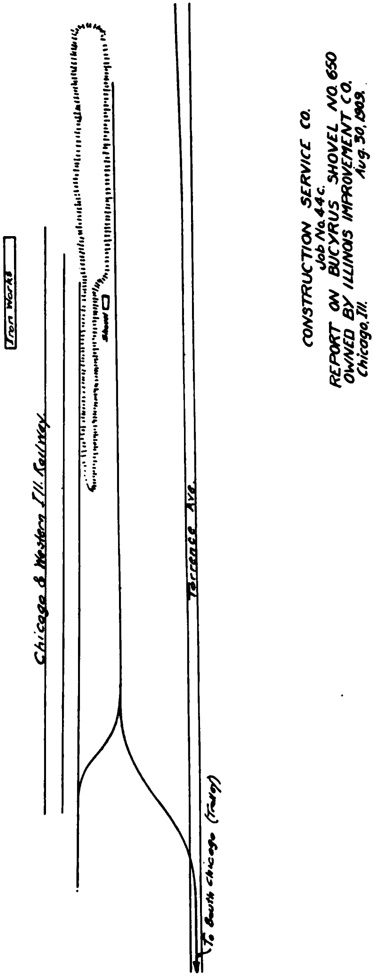
Time for a complete swing

	Minimum	Average	Maximum	No. Obs.
Seconds	14	19 7	26	63

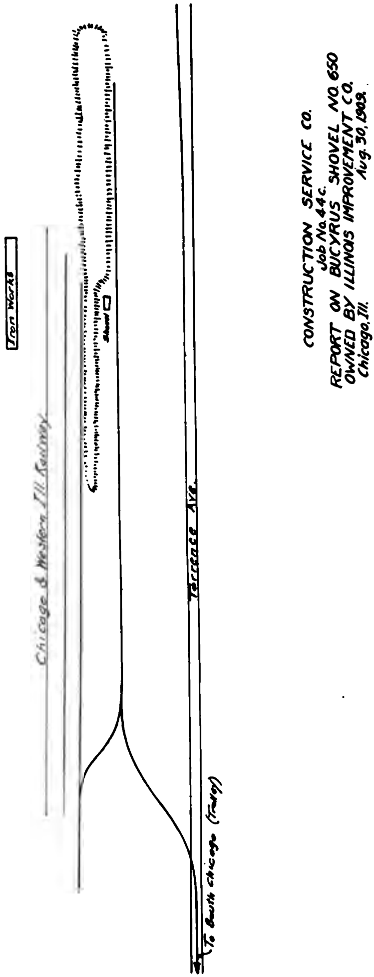
ACTUAL RATIOS

$$\frac{\text{Incidental labor}}{\text{Direct labor}} = 0.094$$

Fig. 25. Bucyrus Shovel No. 650


CONSTRUCTION SERVICE CO.
Job No. 44c.
REPORT ON BUCYRUS SHOVEL NO. 650
OWNED BY ILLINOIS IMPROVEMENT CO.
Chicago, Ill.
Aug. 30, 1909.
Iron Works
Shovel
Chicago & Western Ill. Railway
Terrace Ave.
To South Chicago (Trolley)

Figs. 26 and 27. A 70-ton Bucyrus Shovel at work, South Deering, Ill.


CONSTRUCTION SERVICE CO.
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OWNED BY ILLINOIS IMPROVEMENT CO.
Chicago, Ill.
Aug. 30, 1909.
Iron Works
Chicago & Western Ill. Railway
Shovel
Torrence Ave.
To South Chicago (Trolley)

Figs. 26 and 27. A 70-ton Bucyrus Shovel at work, South Deering, Ill.

REPORT No. 16 — SHOVEL No. 980

INSPECTED AUGUST 28, 1909

CHICAGO, ILL.

THE SHOVEL This shovel of the 70-ton class is owned by the American Brick Company, and is at one of their yards, about 15 miles outside of Chicago, employed in digging clay. The boom and dipper handle are of steel and the boom is truss shaped.

CREW The crew consisted of engineer, craneman and two pitmen. In moving forward the "hooker-on" assisted, making four men for this purpose.

SUPPLIES Water is supplied from a tank located near the buildings. Coal is brought down in one of the dump cars and placed upon the shovel by hand.

POWER Steam power is used to run the brickmaking machinery and to haul the cars up the inclined plane, while horses haul from the shovel to the bottom of the incline.

TRACK AND TRANSPORTATION Three-yard narrow gauge cars are used, which can be dumped on one side only.

The arrangement shown on the sketch and photographs worked satisfactorily, since with four cars the granulator was well supplied with material. The time

for a round trip was obtained several days after the observations were made on the shovel. The shovel was then located at the foot of the incline, so that no horses were necessary and only one car was used. One man at the bottom of the plane hooked the cable to the cars. He also assisted in moving forward.

OBSERVATIONS

Gauge	Standard
Capacity of dipper	2½ yards
Height of lift	A. M., 10′ to 12′; P. M., 14′
Height blocked up	1′
Length of boom	28′
Length of dipper handle	18′ 6″
Height of boom above pivot	21.5′
Height of boom above shovel track	26.5′
Horizontal reach of boom	20′
Farthest dipper can reach to dump	27′
Highest dipper can reach to dump	16′
Diameter of swing circle	7′ 6″
Height of dinkey tracks above shovel tracks (varied from 6 to 8′)	
Distance inside dinkey track to inside shovel tracks	21′
Depth of dipper	4′
Depth of dipper (including lip)	5′
Number of cars loaded	166
Cubic yards excavated	498
Coal used	1.3 tons
Total distance moved forward during day	12′ 4″
Number of times moved forward	2
Maximum distance moved forward in one move	6′ 4″
Average time between beginning of one shovel move and beginning of next	199 minutes
Number of cars to one shovel move	75
Area of section	830 square feet
Height of face	10′ to 26½′, average 18′

Weather, A. M., fair. P. M., cloudy and showery.

TIME STUDY

	Forenoon	Afternoon
Started work	7:00	1:02
Stopped work	12:00	3:53

	Min.		Min.		Min.	
Total time worked	300	+	171	=	471	= 7 hours 51 minutes

	Minutes	Seconds	Per Cent
Actual working	154	30	32.8
Waiting for cars	275	..	58.4
Moving shovel	8	..	1.7
Idle			
Tightening bolts on bull wheel engine	1	..	0.2
Firing	1	..	0.2
Oiling	5	..	1.1
Car off track	21	30	4.6
Repairing track	3	30	0.7
Miscellaneous delays			
Moving boulder	..	30	0.1
Clearing track	1	..	0.2
Total time under observation	471	..	100.0

Direct Labor Distribution per Day	Standard Basis			
	Loading	Trans-porting	Dumping	Total
Runner	$5 00			
Craneman	3.60			
2 pitmen	3.00			
1 hooker-on	...	$1.50		
2 drivers	...	3.00		
2 horses	...	3.00		
Hoisting engineer	...	2.40		
1 dumpman	...	...	$1.50	
Total cost of labor per day	$11.60	$9.90	$1.50	$23.00
Cost per day per cubic yard,	2.33	1.99	0.30	4.62
Per cent	50.4	43.1	6.5	100.0

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to waiting for blasters	..	30	0.1	0.002	0.002
Charge to loading					
1. Actual loading	154	30	32.8	0.764	0.839
2. Delays					
a Moving up	8	..	1.7	0.040	
b Miscellaneous	7	..	1.5	0.035	
Charge to transporting and dumping					
1. Waiting for cars	275	..	58.4	1.361	1.489
2. Repairs	3	30	0.7	0.016	
3. Miscellaneous	22	30	4.8	0.112	
	471	00	100.0	...	2.330

Dipper Performance	Min.	Av.	Max.	No. Obs.	No. Attempts
Digging (Time in Seconds)	5.5	10.7	17	30	30
Swinging loaded (Time in Seconds)	3.0	6.6	14	28	
Swinging empty (Time in Seconds)	4.0	5.5	9	25	
Falling (Time in Seconds)	2.0	2.9	4	20	
Time to fill and load one dipperful	14.5	25.7	44		

Time for a complete swing

	Minimum	Average	Maximum	No. Obs.
Seconds	19	26.2	31.5	19

TRANSPORTATION

	Observations	Hooking-on			Shovel to Bottom of Plane			Waiting at Bottom of Plane			Bottom of Plane to Knives			Waiting and Dumping at Knives			Knives to Bottom of Plane		
		Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
Time (seconds)	8	0	9.4	20	40	58.3	85	55	181	260	15	28.1	40	35	92.5	175	5	11.3	15
Distance (feet)	8	..	...	..	200	200	200	..	...	...	180	180	180	..	...	...	180	180	180
Speed (feet per second)	8	..	...	..	2.4	3.4	5.0	..	...	...	4.5	6.4	12.0	..	...	...	12.0	15.9	36.0

	Observations	Waiting at Bottom of Plane			Bottom of Plane to Point 100 Feet from Shovel			Waiting at this Point			This Point to Shovel			Waiting before Shovel Starts to Load			Actual Round Trip		
		Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
											**						M S	M S	M S
Time (seconds)	8	0	16.9	40	0*	7.5	30	0*	13.1	50	30	30	30	0	13.1	30	5–20	7–57	9–20
Distance (feet)	8	..	...	..	100	100	100	..	...	..	100	100	100	..	...	..	760	760	760
Speed (feet per second)	8	..	...	..	3.3	13.3	...	..	...	..	3.3	3.3	3.3	..	...	..	1.4	1.6	2.3

* Five times out of eight observations cars did not stop at this point, but went direct to the shovel in the average time of 52 seconds.

** Three observations.

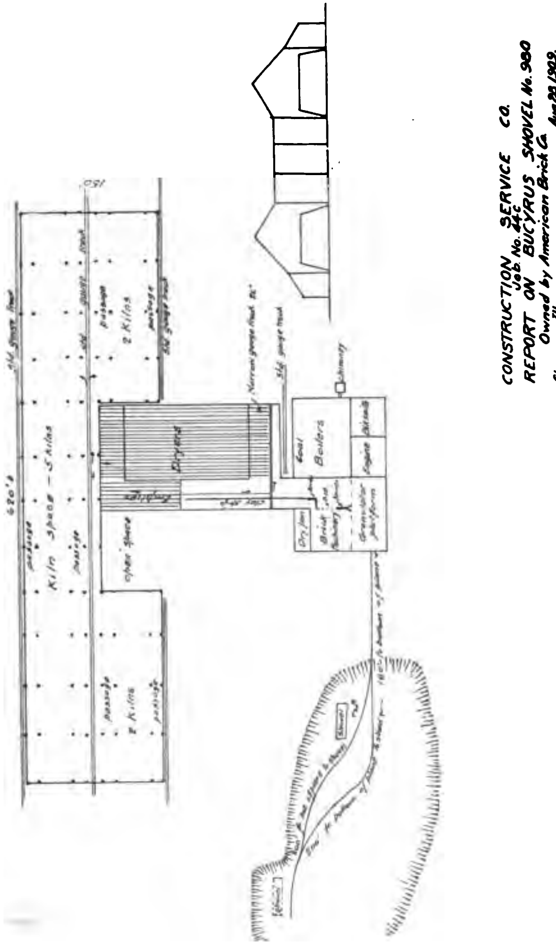

CONSTRUCTION SERVICE CO.
Job. No. 44c
REPORT ON BUCYRUS SHOVEL No. 980
Owned by American Brick Co.
Chicago, Ill.
Aug 28, 1909.
Kiln space — 5 kilns
2 Kilns
Dryers
Boilers
Coal
Engine
Granulator platform
Dry pan
Chimney

Fig 28

Fig. 29. 70-ton Bucyrus Shovel Digging Clay in Pit of American Brick Company, Chicago, Ill.

REPORT No. 17 — SHOVEL No. 424

INSPECTED SEPTEMBER 2, 1909

RIVERDALE, ILL.

LOCATION Bucyrus steam shovel No. 424, owned by the Chicago Brick Company, is located in one of their clay pits at Riverdale.

THE SHOVEL The machine was new when the brick company bought it and has been used by them ever since (now about eight years) to dig out clay. A chain is used for hoisting, but the swinging is done with a steel cable. The cutting edge of the dipper is a solid plate extending 18 inches beyond the lip and riveted to the latter, being rounded off and drawn out to a sharp edge in front. The face against which the shovel works is very high (26 feet) and it frequently caves in, sometimes falling upon the dipper, causing considerable strain on the dipper handle and crane engine.

MATERIAL The clay in the pit is very heavy, but is not blasted before digging. The shovel shows no undue strain when digging, but several times the dipper handle has been thrown out so far that it has been caught on the tie bars holding the boom and has bent them considerably. As there is often considerable sand in seams and layers between the clay, the engineer has to judiciously mix it so that the clay will not be too "short" for good bricks. This causes the digging to be very uneven at times, since on one side there will often be good clay, and on the other poor sand.

LABOR The engineer does his own firing and the craneman superintends the moving forward. One of the two pitmen sees that the track is not obstructed, throws the switch for the cars, the other looking after the jacks and the pit.

SUPPLIES Coal is brought out in one of the clay cars and thrown upon the shovel by the pitmen, usually after the loading is stopped in the afternoon, when enough coal is taken to last throughout the following day. Water is obtained from a pipe line leading from the mill.

TRANSPORTATION The cars are all provided with two horse-power motors, to which current at 125 volts is supplied through a third rail in the middle of the tracks. The capacity of the cars is 3.12 cubic yards, but they are heaped full. They dump on one side only. The top of each car is five feet above the track. They do not move very fast, but their motion is constant and the service is satisfactory. The steepest grade is 5 per cent against the empties, but even here the speed is noticeably reduced, so that it is not likely that cars of such low horse-power would be of use to a contractor under the usual conditions. Seven horse-power cars were tried on this track, but were found to be too fast and easily became derailed. The cars are run by one man, who controls switches located at about the center of the system, which is divided into seven circuits, each controlled by a single-pole knife switch, so that the operator can control each individual car at any time and at any place along the line. At the end of each branch, or where a car is switched back on another track, the reverse switch is thrown by an automatic contrivance, which is simply a small steel frame with a bent bar that knocks the reverse lever up as the car passes by. At the end of the line, where the cars are loaded, one of the pitmen knocks down the lever when the car is ready to start, and the switchman, seeing this done from his shed, closes the switch for that circuit. When the cars run out to the shovel the switchman has to open the circuit when they near the end; then, just as they strike the bumper, which

is part of an old hoisting chain wrapped around one rail, the pitman places a block under the wheels. The third rail runs to the foot of the incline, where a wire cable is attached, and are drawn up by an electrically operated hoisting engine.

All the switches work automatically by springs, there being no one to attend to the cars after they pass the switchman and until they arrive at the foot of the incline, where a man attaches the cable.

There are two granulators in the mill, but at present only one is in use so that the shovel is often delayed waiting for the cars to be dumped and returned. When both machines are run, however, there is more work for the shovel, and a fireman is furnished.

Ground up brick powder is used on the rails in place of sand to keep the shovel wheels from slipping when moving up.

OBSERVATIONS

Weight	65 tons
Gauge	Standard
Capacity of dipper	2½ cubic yards
Height of lift	6′
Kind of teeth	Cutting lip
Number of pitmen	2
Height blocked up	1′
Length of boom	28′
Length of dipper handle	18′ 6″
Height of boom above pivot	20′
Height of boom above shovel track	25′
Horizontal reach of boom	19′ 6″
Farthest dipper can reach to dump	27′
Highest dipper can reach to dump	16′
Diameter of swing circle	7.5′
Height of dinkey tracks above shovel tracks	25′
Distance inside dinkey tracks to inside shovel track	15′

OBSERVATIONS—*Continued*

Depth of dipper	48″
Depth of dipper, including lip	62″
Depth of dipper, including cutter blade	80″
Number of cars loaded	158
Cubic yards excavated (place measure)	474
Total distance moved forward during day	8′
Number of times moved forward	3
Maximum distance moved forward in one move	3′
Average time between beginning of one shovel move and beginning of next	152 minutes
Number of cars to one shovel move	50
Time shovel is interrupted to change trains	283 minutes

TIME STUDY

	Forenoon	Afternoon
Started work	6:54:00 9:13:30	11:48
Stopped work	8:59:30 11:09:00	3:42:30

Total time worked 241 Min. + 234½ Min. = 503½ Min. = 7 hours 55 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	160	30	33.8
Waiting for cars	283	00	59.5
Moving shovel	11	00	2.3
Idle			
Engineer firing	4	30	0.9
Axle box knocked out of car	11	00	2.3
Tightening jacks	0	30	0.1
Miscellaneous delays			
Clearing track	5	00	1.1
Total time under observation	475	30	100.0

Direct Labor Distribution Per Day	Standard Basis				
	Loading	Trans-porting	Dump-ing	Inci-dentals	Total
Runner	$5.00	...	...	...	...
Craneman	3.60	...	...	...	...
2 pitmen	3.00	...	...	...	...
1 controllerman	...	$2.60	...	...	...
1 cableman	...	1.50	...	...	...
1 hoistman	...	1.50	...	...	...
1 cardumper	...	...	$1.50	...	...
1 watchman	...	...	...	$1.50	...
Total cost of labor per day	$11.60	$5.60	$1.50	$1.50	$20.20
Cost per cubic yard	2.45	1.18	0.32	0.32	4.27
Per cent	57.4	27.6	7.5	7.5	100.0

Process Analysis	Time		Per Cent	Charge Cents	Total
	Min.	Sec.			
Loading					
1. Actual loading	160	30	33.8	0.828	0.909
2. Delays					
a Moving up	11	00	2.3	0.056	
b Miscellaneous	5	00	1.0	0.025	
Transportation and dumping					
1. Waiting for cars	283	00	59.5	1.458	1.541
2. Miscellaneous	16	00	3.4	0.083	
	475	30	100.0	...	2.450

TRANSPORTATION

	Observations	Shovel to Switch No. 1			Waiting at Switch No. 1			Switch No. 1 to Bottom of Plane			Waiting at Bottom of Plane			Bottom of Plane to Knives			Waiting and Dumping of Knives		
		Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
Time (seconds)	8	50	62	80	00	00	00	30	74	100	105	284	415	35	44	50	90	109	135
Distance (feet)	8	350	350	350	..	..	..	648	648	648	...	...	...	190	190	190	..	...	...
Speed (feet, seconds) . . .	8	4.4	5.6	7	..	..	..	6.5	8.8	21.6	...	...	...	3.8	4.3	5.4	..	...	...

	Observations	Knives to Bottom of Plane			Waiting at Bottom of Plane			Bottom of Plane to Switch No. 4			Waiting at Switch No. 4			Switch No. 4 to Shovel			Actual Round Trip		
		Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
																	M S	M S	M S
Time (seconds)	7	20	27	40	00	00	00	90	118	140	00	00	00	40	63	90	11–30	13–10	14–30
Distance (feet)	7	190	190	190	..	..	..	763	763	763	..	..	..	410	410	410	25 51	25 51	25 51
Speed (feet, seconds) . .	7	4.8	7.0	9.5	..	..	..	5.5	6.5	8.5	..	..	..	4.6	6.5	10.3	2.9	3.2	3.7

REPAIRS

We were given, by permission, the following interesting statement of repairs for 6½ years, not including labor:

YEAR 1903

February	13	1 cutter blade, 1¼″ x 16″ x 44″ mild steel. Plate bent and drilled 6.1″ x 3¾″; bolts, same.
June	7	2 valve stems for boom engine, 2 pins for same.
June	15	1 hoisting chain for shovel (1¼″ x 122′); 1 cutter blade, 1¼″ x 15″ x 44″.
July	20	1 friction brake complete with band; 12 hard wood blocks.
September	18	Four 4⅜″ cylinder cocks.
October	9	12 countersunk bolts, 3¾″, and nuts; 50 turned bolts, ⅞″ x 5″ nuts.
November	27	1 swinging cable, 1¼″ x 48′; 1 swinging cable, 1¼″ x 52′ — 100′

YEAR 1904

June	24	1 swinging cable, 1¼″ x 48′; 1 swinging cable, 1¼″ x 52′ — 100′
July	9	60 forged rack bolts
July	15	8 forged rod bolts, 1⅝″ x 22″; 1 forged rod bolt, 2″ x 30″ — 156 pounds. 50 turned bolts, ⅞″ x 4″, 61 pounds.
August	3	3 bolts, 1″ x 2¼″, and nuts
September	21	Two 2¾″ hexagon nuts, as per sample

YEAR 1905

January	13	2 steel jack plates, 155 pounds
February	8	2 cutter blades, 1¼″ x 16″ x 44″
June	9	2 nests standard 4-coil truck springs
August	25	2 bearings with caps and bolts for same (used on dipper shaft).
September	16	1 long toggle lever, No. 9133B; 1 double forked link and pin; 2 short toggle links and pins; 1 double forked link pin; 1 toggle link pin; 1 latch keeper, 54 pounds.

September	14	Two 2½″ bolts, 34″ long, 127 pounds; two 2¾″ bolts, 34″ long, 137 pounds.
October	14	60 tack bolts 10 turned bolts } 105 pounds. 40 turned bolts 8-1⅝″ x 22″ rod bolts 12-1″ x 3¾″ countersunk bolts } 143 pounds 8-¾″ x 2″ countersunk bolts
November	8	2½″ x 12″ plates drilled complete, 56 pounds; rivets for same, 17 pounds

YEAR 1906

March	10	1 shipper shaft, No. 1–9157, 232 pounds; one 1½ moran joint; 12 small screws as per sample; 6 large screws as per sample; 36 copper rivets; 2 rack pinions with key for same; 1 set keys for same.
May	24	. . . . One 3″ throttle valve complete
June	14	One 1¼″ x 122′ hoisting chain, 214 pounds; one 1¼″ x 52′ swinging cable; twenty-seven ⅞″ x 3⅛″ finished bolts and nuts, 30 pounds; twenty-four ⅞″ x 5½″ finished bolts and nuts, 37 pounds; six ⅜″ locomotive cylinder cocks; 2 steel bushings for dipper bail.
September	8	. Two 1½″ x 27″ bolts, 4″ thread on each end
September	13	. . . . . . 1 jack nut, No. 9011, 205 pounds
October	4	. . . . . . 1 jack nut, No. 9011, 202 pounds
October	5	14 bushings; 2 V. S. pins; 4 ecc. rods pins.
October	25	1 rocker shaft bearing, 2 rocker shaft bearings, 2 common rods for valve stems with pins.
December	11	1 cutter blade, 1¼″ x 18″ x 44″; two 2¾″ hexagon nuts.

YEAR 1907

June	1	. . . . 52′ of 1¼″ ex. flex. plow steel rope
June	27	Twelve ⅞″ finished bolts, 5″ long with nuts, 38 pounds; twelve ⅞″ finished bolts, 5½″ long with nuts, 38 pounds; twelve 1⅝″ x 22″ rod bolts with nuts, 206 pounds.
July	3	2 bushing No. 2 standard 13; 1 pin, 1¾″ x 38″ long, 7-9030.

YEAR 1908

September 22 One 1¾″ turnbuckle, 9140; 1 hoop end S. N. bracer, 9140; 2 lower boom guys, 10-9140; 2 upper boom guys, 9-9140, with pins and bolt, 1233 pounds; 1 A. frame collar pin and bolts, 140 pounds; 1 thorough bolt and nuts.

YEAR 1909

March	24	Two 2¾″ x 34″ holding down bolts, 139 pounds.
April	26	1 Fulcrum bracket, 9139 A; 1 Fulcrum bracket pin, 1-9135.
April	7	1 swinging cable, 1¼″ x 48′; twenty-four ⅞″ finished bolts, 5″ long hexagon nuts; twenty-four ⅞″ finished bolts, 5½″ long hexagon nuts; 2 braces for cross-head pins, 9525 A; 2 cross-head pins with nuts, 1-9549.
May	10	1 cutter blade, 1¼″ x 18″ x 44″ plat.
June	1	Two 1¼″ U-bolts, 5-9176, and nuts, 214 pounds.
June	15	Six 1½″ x 22½″ bolts with hexagon nuts; 20-pound ¾″ lock washer, 340 washers.
July	23	One 1500-gallon tank complete.
August	21	1 hatch keeper, 10-9030, 51 pounds.

	Summary	Cost
1903		$273.20
1904		70.88
1905		138.20
1906		375.12
1907		47.55
1908		116.43
1909		266.86
	Total for 6½ years	$1288.24
	To this must be added, for boiler repairs, including labor	200.00

Per Year

Maximum = $375
Average = 198
Minimum = 48 Not including boiler.

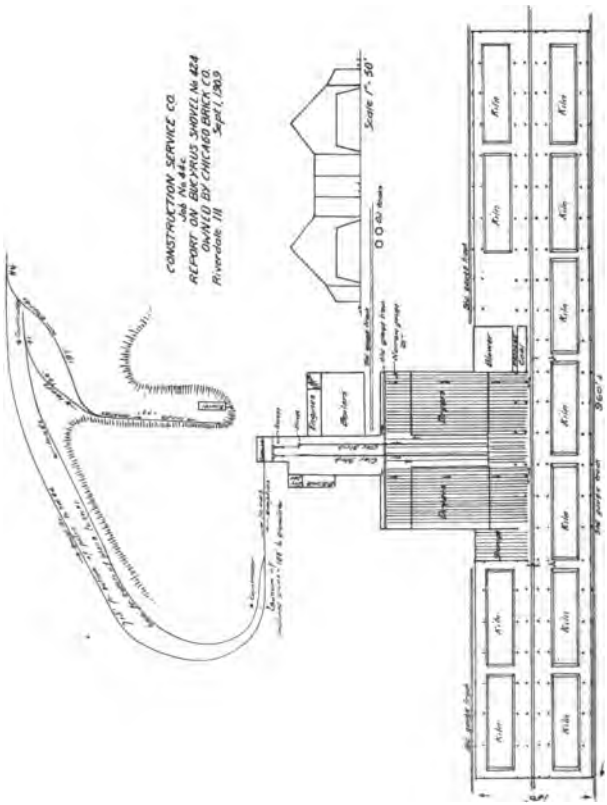

CONSTRUCTION SERVICE CO.
Job No. 44c
REPORT ON BUCYRUS SHOVEL No 424
OWNED BY CHICAGO BRICK CO.
Riverdale Ill
Sept 1, 1909
Scale 1" = 50'
Kiln
Boilers
Engines
Blower
Dryer
360'

Fig. 30

Fig. 31. Two Views of Clay Pits owned by the Chicago Brick Co., showing Tracks and a Bucyrus Shovel

REPORT No. 19 — SHOVEL No. 517

INSPECTED OCTOBER 4, 1909
BUHL, MINN.

LOCATION Butler Brothers have two shovels working on their stripping contract in the Grant Mine (see p. 123). This is a new project, the mine undergoing the first stripping at the present time although heretofore ore has been taken from underground.

MATERIAL In a cut about 900 feet long and 200 feet wide, which represents the limit of operations at present, nearly every kind of material met with on the Mesabi has been encountered. The top is clay and loam almost entirely free from boulders. In places this clay seems to retain its moisture and is heavy, damp and sticky, hard to dig out of the bank and harder to dislodge from the dipper. In other places the clay was impregnated with iron and was dry and crumbling. This was easy to handle. At some points boulders were intermingled with the dry material, and while in general they were not large they interfered considerably with the digging. At about 30 feet from the surface was a layer of boulders varying in size from 8 inches to 5 feet in thickness. These lay with almost no material between them, a clean mass of stones that looked as if they had been picked and placed by hand. This presents perhaps the most difficult work to be encountered by a steam shovel in any locality. Extra heavy teeth are often bent and broken so as to be utterly useless. A couple of small pockets of gravel were uncovered. Solid taconite and taconite mixed with earth, and low grade ore in a clean body and also mixed with taconite were encountered.

Shovel No. 517 was working in soft clay mixed with boulders. These boulders were not very large nor were

they massed, but were scattered through the clay in such a manner as to be readily picked up with it. Most of them passed through the dipper without trouble. When a boulder too large to handle was uncovered it was thrown to the side of the pit away from the loading track and as far back as possible. For the day's work these boulders averaged less than one per "shovel move."

The shovel bank was very low—too low for economical work. At the beginning of the day the bank on the extreme right of the cut was high enough to allow the dipper to be filled at one trial. After three hours' work the shovel experienced greater difficulty in filling dipper. For the first seven moves, while working with the high bank at one side, the shovel averaged nearly a car to the move more than during the remainder of the day.

The low bank also had its effect upon the time per dipper. For the first 7 trains the average time per dipper was 22.07 seconds while for the rest of the day the average time was 26.83 seconds, an increase of 21 per cent.

MOVING UP The pit could be kept clean because the bank ahead was not high enough to cave into it. For this reason it was found possible to lay the track before the signal was given for the move-up, which of course necessitated working in the pit and in front of the shovel while it was working, a rather dangerous procedure. While the runner never stopped his dipper because of the men below, their presence made him more cautious and it is to be doubted whether he was able to operate quite as fast and freely as would have been the case with a clear pit.

The moves of the shovel were unusually difficult because of the curve of the track, and consequently the time per move cannot be compared with that for other shovels with ordinary moves and ordinary methods.

Whatever time is gained on the actual move is probably lost by the more cautious work of the runner while the track is being laid, and although this cautious running may not be individually noticeable, its effect on a whole day's work is important.

SHOVEL The jack blocks for this shovel were slightly different from the ordinary ones. Mr. Butler said that they had been trying different kinds and had found that pyramiding several thin ones was better than the use of large heavy blocks. The ground block in this case was 4 feet by 6 feet, composed of 3 layers of 2-inch by 10-inch stuff. The top and bottom members run the 6 feet length of the block. The next block was 3 inches by 3 inches by 4 inches thick, the next 2 feet 6 inches by 2 feet 6 inches by 4 inches and the top block 2 feet by 2 feet by 4 inches. The jack plate rested on this with a base about 1 foot square. The plate was free from both block and jack.

Extra large and strong teeth are necessary in this mine because of the nature of the digging. Teeth weighing 460 pounds each are used and these are often bent and broken. One tooth was observed which had been bent over and down until it lay against the lip of the dipper.

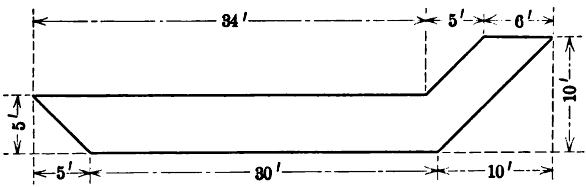
In attempting to move a large boulder from the front part of the pit it became jammed in the dipper. The craneman was carrying the boulder on the dipper teeth and it toppled into the dipper. Being too large to go through, it caught on the back of the dipper and the entire shovel crew, the rockmen, the coal passer and the train crew of three men 64 minutes and 10 seconds to remove it.

The bolster of the front truck has been reinforced with four plates, ¾″ x 6″, riveted to the sides of the two regular I-beams; and the A frame, which is of the built-up type, has been reinforced with plates along its side.

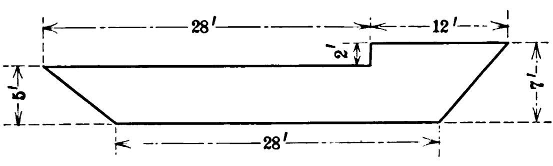
The lower chord of the boom truss has a 1″ x 6″ plate riveted to its underside and extending the length of the open part of the boom.

OBSERVATIONS

Type of shovel . . . . Bucyrus, 75-ton
Distance of move . . . . 5′ 4″
Kind of teeth . . . . . Very heavy, weigh 460 pounds
This is the section of bank when shovel started working.



It was turning slightly to the left, and at 9.45 cut out of bank left by old loading track and section became



Height of lift . . . { Cars above rail . . . . . . 7′ 3″
Shovel track to loading track, 5′ minus }
Size of ties under shovel . . . . 6″ x 6″ and 6″ x 8″
Size of bucket . . . . 2½ yards
Length of shift . . . . 10 hours
Number shifts per day 2
Coal is dumped from dump car back of shovel and is carried in basket to bunker by man.
Water is piped from underground mine nearby and run in pipe over side of cut.

Repairs are made on Sundays and when needed.
Coal used . . . . 2½ tons per shift
Water used . . . . 4200 gallons per shift
Boiler is cleaned every two weeks.
Kind of track . . . . Standard; 60-pound rails
7-yard Russell Wheel and Foundry cars used.
Locomotive braked by air.
Hand signals used.
Kind and size of dinkey . . Standard locomotive, 50-ton ±
Number of trains 2
Age of cars and dinkey. New on this job. Bought early in 1909
Weather, fair, rather cold.

TIME STUDY

	Forenoon	Afternoon
Started work	6:55:20	12:55:15
Stopped work	11:58:00	6:00:10

	Min.	Sec.		Min.	Sec.	
Total time worked	302	40	+	304	55	= 10 hours 7 minutes 35 seconds.

	Minutes	Seconds	Per Cent
Actual working	296	40	48.8
Waiting for cars	46	30	7.7
Moving shovel	141	35	23.3
Miscellaneous delays			
Fixing bale pin	4	45	0.8
Boulder on track	1	25	0.2
Fixing bale pin	2	55	0.5
Clearing track	6	0	1.0
Tightening jack	0	35	0.1
Putting on new bale pin . . .	11	10	1.8
Boulder on track	2	30	0.4
Loading old teeth	6	30	1.1
Repairs to locomotive . . .	6	45	1.1
Pulling timber from pit . . .	1	20	0.2
Rock in teeth	1	05	0.2
Dumping coal from car . . .	3	30	0.6
Repairs to locomotive . . .	5	10	0.8
Rock stuck in dipper . . .	64	10	10.6
Rock in teeth	1	30	0.2
Car off track	3	30	0.6
Total time under observation . .	607	35	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	\$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6 00
2 track cleaners	3.00
1 coal carrier	1.50
	\$21.50

Car loads excavated on day of observation, 156 @ 7 cubic yards per car, water measure.

Cubic yards loaded on day of observation, $156 \times 7 \times 0.75^{*} = 820$.

Cost of labor per day per cubic yard $= \frac{\$21.50}{820} = 2.62$ cents per cubic yard.

$^{*}0.75 = \text{ratio of } \frac{\text{Place measure}}{\text{Water measure}}$

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to loading					
1. Actual loading	296	40	48.8	1.279	2.308
2. Delays					
a Moving up	141	35	23.3	0.610	
b Repairs	18	50	3.1	0.081	
c Miscellaneous	78	40	12.9	0.338	
Charge to transporting and dumping					
1. Waiting for cars	46	30	7.7	0.202	0.312
2. Repairs	11	55	2.0	0.052	
3. Miscellaneous	13	25	2.2	0.058	
	607	35	100.0	....	2.620

Time Study Deductions	Number Observations	Minimum Min.	Minimum Sec.	Mean Min.	Mean Sec.	Maximum Min.	Maximum Sec.
Time of moving up, shovel idle . . .	22	3	10	6	26	11	00
Time between moves, shovel working . .	23	9	10	12	53.6	17	00
Time between trains .	14	2	10	3	13.5	5	35
Time per train, loading	16	12	40	19	01	25	00
Time per dipper . .	23	..	14	.	25.2	..	35
No. of dippers to move	23	24		30.8		38	
No. of dippers to train	15	36		44		47	
No. of dippers to cars	..	..		4 54		..	

Number of trains loaded 16
Number of cars loaded 156
Number of cars per train . { First and last trains 8 cars each, others 10 each

ANALYSIS OF COMPLETE DIPPER SWING

Where only one trial was necessary to obtain dipperful

	Observations	Minimum Seconds	Average Seconds	Maximum Seconds
Digging	28	3.60	6.00	9.60
Swinging over . . .	37	4.00	5.74	7.20
Swinging back . . .	34	2.80	7.49	9.60
Total	..	10.40	19.23	26.40

Where more than one trial was necessary to obtain dipperful

	Observations	Minimum Seconds	Average Seconds	Maximum Seconds
Scratching	18	4.80	5.76	8.00
Digging	19	6.20	9.08	11.40
Swinging over . . .	23	4.00	6.08	8.00
Swinging back . . .	20	6.80	7.90	9.60
Total	..	21.80	28.82	37.00

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{35{,}000}{5{,}000} = 7.00$$

EXPLANATION OF TIME STUDY

We give with the description of this shovel's work, the complete time study on it, to indicate how an operator may get up such information as is given in this report for himself.

The starting point of the study and the feature upon which all figures are based is the shovel move, and the attempt has been made to make the study read from this in logical order. By reading across the lines, the complete day's work of the shovel can be followed.

Let us take the time study for No. 517 and follow it through in explanation:

The day's work began at 6.55.20. From the blowing of the whistle to the time when the first train came up to be loaded was 5 minutes 10 seconds, and is called "Waiting for first train" under "Miscellaneous Delay," in column No. 8. After the train arrived, 4 minutes 45 seconds were occupied in repairing a bale pin, and then the shovel started loading. That these two delays came before the loading began is shown by the figures occupying lines above that in which the first "Loading time" is given, and the fact that they are successive delays is shown by their being on different lines.

The shovel loaded the first train in 15 minutes 30 seconds, as shown in column No. 2, and this required 37 swings. Only one train was loaded on this move, as is shown by the fact that "Loading time of train," column No. 2, and "Working per move," column No. 4, are identical and by the fact that the "Dippers per train," column No. 3, and "Dippers per move," column No. 6, are identical. During the loading of the train a delay of 1 minute 25 seconds, because of "boulder" on track, is noted in column No. 8.

This move having been finished and the train loaded, the shovel next moved up in 7 minutes 5 seconds, as

shown in column No. 1, and loaded for 15 minutes, making 38 swings in that time.

The shovel moves again in 6 minutes 5 seconds and loads for 3 minutes 50 seconds or 9 swings, filling the train. There follows a wait of 2 minutes 35 seconds for the next train. When this train came up it loaded 22 dippers in 9 minutes 20 seconds and the shovel then moved up. The shovel worked on this move 3 minutes 50 seconds on one train and 9 minutes 20 seconds on the next, or a total of 13 minutes 10 seconds (column No. 4) and in that time loaded 31 dippers at an average rate of .424 minute per dipper. During the loading of 22 dippers on the last train, 2 minutes 55 seconds were consumed in "fixing bale pin," 11 minutes for the move, and, after starting to load, 22 dippers were dumped in 8 minutes 15 seconds, filling the train. The total loading time of the train and the total number of dippers are not given but are the sums of the figures in bracket, in this case 9 minutes 20 seconds plus 8 minutes 15 seconds=17 minutes 35 seconds for loading time of 44 dippers.

After filling the train a delay of 3 minutes 15 seconds followed while waiting for the next train. When this arrived the shovel loaded 10 dippers in 3 minutes 40 seconds and then moved up. Besides the 3 minutes 40 seconds consumed in loading this train, 8 minutes 15 seconds were used on the previous train, or a total loading time for the move of 11 minutes 55 seconds, 32 dippers being loaded. During the loading of the last 10 dippers 6 minutes were needed to clean the track.

The move up took 5 minutes 50 seconds and was followed by 9 minutes 25 seconds of loading when the train was full, having taken 36 dippers on this move and 10 on the previous one, or 46 altogether. That the entire move was needed to load this train is shown by the fact that figures in column Nos. 2 and 4, and in Nos. 3

and 5 are the same. The next move up took 7 minutes 15 seconds, and the train came up in 3 minutes 45 seconds. These 3 minutes 45 seconds were then not lost, as the time occurred during the 7 minutes 15 seconds, and is put in parentheses to show that it is not to be counted as lost time.

After the move occupying 7 minutes 15 seconds, the shovel loaded 30 dippers in 11 minutes and moved up again. The total working time of this move was 11 minutes and the total dippers were 30. After the next move, which took 5 minutes 45 seconds, the shovel loaded 16 dippers in 4 minutes 50 seconds and the train was full. The next train was up in 5 minutes 35 seconds and loaded 16 dippers in 6 minutes, before the shovel had to move. After the move, which took 5 minutes 50 seconds, 31 dippers were loaded in 11 minutes 35 seconds and the train was full. These 31 dippers also made another move up necessary.

To make the notes clearer the time of any one train has been put in brackets. The time per train, however, is not essential, the essential time bein[illegible] on the moves rather than on the trains. [illegible] must be kept in mind constantly in read[illegible] study notes.

The "Miscellaneous delays" i[illegible] have occurred e[illegible]ing the l[illegible] whose line they [illegible]or after [illegible] That is a detail [illegible] no di[illegible] time is shown to [illegible] lost.

The total wor[illegible] give[illegible] head of the shov[illegible] The number of [illegible] page, together [illegible] [illegible]ther facts [illegible] [illegible]rked [illegible] [illegible]

shown in column No. 1, and loaded for 15 minutes, making 38 swings in that time.

The shovel moves again in 6 minutes 5 seconds and loads for 3 minutes 50 seconds or 9 swings, filling the train. There follows a wait of 2 minutes 35 seconds for the next train. When this train came up it loaded 22 dippers in 9 minutes 20 seconds and the shovel then moved up. The shovel worked on this move 3 minutes 50 seconds on one train and 9 minutes 20 seconds on the next, or a total of 13 minutes 10 seconds (column No. 4) and in that time loaded 31 dippers at an average rate of .424 minute per dipper. During the loading of 22 dippers on the last train, 2 minutes 55 seconds were consumed in "fixing bale pin," 11 minutes for the move, and, after starting to load, 22 dippers were dumped in 8 minutes 15 seconds, filling the train. The total loading time of the train and the total number of dippers are not given but are the sums of the figures in bracket, in this case 9 minutes 20 seconds plus 8 minutes 15 seconds=17 minutes 35 seconds for loading time of 44 dippers.

After filling the train a delay of 3 minutes 15 seconds followed while waiting for the next train. When this arrived the shovel loaded 10 dippers in 3 minutes 40 seconds and then moved up. Besides the 3 minutes 40 seconds consumed in loading this train, 8 minutes 15 seconds were used on the previous train, or a total loading time for the move of 11 minutes 55 seconds, 32 dippers being loaded. During the loading of the last 10 dippers 6 minutes were needed to clean the track.

The move up took 5 minutes 50 seconds and was followed by 9 minutes 25 seconds of loading when the train was full, having taken 36 dippers on this move and 10 on the previous one, or 46 altogether. That the entire move was needed to load this train is shown by the fact that figures in column Nos. 2 and 4, and in Nos. 3

and 5 are the same. The next move up took 7 minutes 15 seconds, and the train came up in 3 minutes 45 seconds. These 3 minutes 45 seconds were then not lost, as the time occurred during the 7 minutes 15 seconds, and is put in parentheses to show that it is not to be counted as lost time.

After the move occupying 7 minutes 15 seconds, the shovel loaded 30 dippers in 11 minutes and moved up again. The total working time of this move was 11 minutes and the total dippers were 30. After the next move, which took 5 minutes 45 seconds, the shovel loaded 16 dippers in 4 minutes 50 seconds and the train was full. The next train was up in 5 minutes 35 seconds and loaded 16 dippers in 6 minutes, before the shovel had to move. After the move, which took 5 minutes 50 seconds, 31 dippers were loaded in 11 minutes 35 seconds and the train was full. These 31 dippers also made another move up necessary.

To make the notes clearer the time of any one train has been put in brackets. The time per train, however, is not essential, the essential time being based on the moves rather than on the trains. This fact must be kept in mind constantly in reading all time study notes.

The "Miscellaneous delays" in column No. 8 may have occurred either during the loading of the train on whose line they appear or after that train is loaded. That is a detail that makes no difference so long as the time is shown to have been lost.

The total working day is given in its two parts at the head of the sheet and is reduced to minutes and seconds. The number of trains loaded is given at bottom of the page, together with the number of moves worked, and such other facts as may be pertinent. The number of moves worked will be the same as the number of items in column No. 4 and may be the same as the number of items in column No. 1, or may be one less than this.

EXPLANATION OF TABLES OF "TIME OF DIFFERENT PARTS OF DIPPER ACTION"

This time study was made by two methods. To properly fill the dipper it was often necessary to make two lifts. For this reason different sets of figures were obtained to cover each condition.

In table No. I only one movement of the dipper was needed to get a full load. Where two trials were made the figures have been put in parentheses and omitted from the totals and averages, but when the times of swinging are not thereby affected they are shown. An attempt was made to divide the time of the two trials equally, but it was seen that this would not give true values.

In table No. II the first digging movement of the dipper is called "scratching," not only to indicate it more clearly, but because that is what the process really is. The material of the bank is simply loosened and falls down into the bottom of the pit, where it is picked up by the dipper on the next trial.

The time for "scratching" was taken from when the throttle of the hoisting engine was open to that when it was closed. The time of "digging" then is the time required to drop the dipper to the bottom of the pit and raise it, picking up a load in the meantime, and ends when the "swing over" starts. This it will be seen is not a fair apportionment of time to this item of the dipper action, as it is too great by the time required to drop the dipper.

When the dipper was filled in one trial in table No. II the time of that dipper is put in parentheses and not counted in the total and average, as in these cases a different condition obtains. The average of these times, 510, is seen to be near the average for "digging" in table No. I.

Wherever a figure is widely different from the other figures of a column it has been enclosed in parentheses and left out of the average.

TIME STUDY. SHOVEL No. 517

	Hrs.	Min.	Sec.		Hrs.	Min.	Sec.
Began work . .	6	55	20	Began . . .	12	55	15
Noon	11	58	00	Stopped . .	6	00	10

Total work, 10 hours 7 minutes 35 seconds, or 607 minutes 35 seconds

Read left to right and down

Moving Up Min.	Moving Up Sec.	Loading Time of Trains Min.	Loading Time of Trains Sec	Dippers per Train	Working per Move Min.	Working per Move Sec.	Dippers per Move	Time per Dipper Min.	Waiting Between Trains Min.	Waiting Between Trains Sec.	Miscellaneous Delays Min.	Miscellaneous Delays Sec.	Miscellaneous Delays
. .	.	. .	.	. .	. .	.	. .	. .	. .	.	5	10	Waiting for first train
. .	.	. .	.	. .	. .	.	. .	. .	. .	.	4	45	Fixing bale pin
. .	.	15	30	37	15	30	37	.420	(3	20)	1	25	Boulder on track
7	05	15	00)	38	15	00	38	.395	.	.			
6	05	3	50)	9	. .	.	. .	. .	2	35			
. .	.	9	20)	22	13	10	31	.424	. .	.	2	55	Fixing bale pin
11	00	8	15)	22	. .	.	. .	. .	.	.			
. .	.	. .	.	. .	. .	.	. .	. .	3	15			
. .	.	3	40)	10	11	55	32	.370	. .	.	6	00	Cleaning track
5	50	9	25)	36	9	25	36	.263	(3	45)	0	35	Tightening jack
7	15	11	00)	30	11	00	30	.366	. .	.			
5	45	4	50)	16	. .	.	. .	. .	. .	.			
. .	.	. .	.	. .	. .	.	. .	. .	5	35			
. .	.	6	00)	16	10	50	32	.340	. .	.			
5	50	11	35)	31	11	35	31	.372	. .	.	11	10	Putting new bale pin
6	15	11	15)	30	11	15	30	376	(3	30)	2	30	Boulder on track
5	10	4	20)	13	. .	.	. .	. .	. .	.	6	30	Loading old teeth
. .	.	. .	.	. .	. .	.	. .	. .	2	50			
. .	.	6	10)	18	10	30	31	.338	. .	.			
8	20	9	10)	29	9	10	29	.316	.	.			

TIME STUDY. SHOVEL No. 517—Continued

	Min. Sec.	Min. Sec.		Min. Sec.		Min.	Min. Sec	Min. Sec.	
	11 30	9 30)	28	9 30	28	.339	(4 00)		
	6 00	6 00)	19	...	..	..	...		
	...	...	..	...	..	..	3 10		
	...	5 40)	10	11 40	29	.404	...		
	5 50	1 50)	5	...	..	..	...		
	Noon	...	..	...	..	..	...		
	...	13 10)	24	15 00	29	.518	...	6 45	Repairs to locomotive
	...	...	..	...	..	..	...	1 20	Pulling timber from pit
	4 40	7 00)	9	...	..	..	...	1 05	Rock in teeth
	...	...	..	...	..	..	2 55	3 30	Dumping coal from car
	...	...	..	...	..	..	...	5 10	Repairing locomotive
	...	7 00)	19)	14 00	28	.500	...	64 10	Rock stuck in dipper
	5 10	14 20)	28)	14 20	28	.510	...		
	5 10	15 40)	32)	15 40	32	.492	(4 20)		
	4 00	2 00)	4)	...	..	..	...		
	...	...	..	...	..	..	2 10		
	...	12 00)	27)	14 00	31	.452	...		
	5 30	7 00)	20)	...	..	..	...		
	...	...	..	...	..	..	3 30		
	...	7 50)	12	14 50	32	.465	...		
	6 00	13 40)	30	13 40	30	.456	...		
	...	...	..	...	..	..	(12 20)*		
	3 10	16 30)	30	16 30	30	.550	...		
	6 30	8 30)	14	...	..	..	...		
	...	...	..	...	..	..	3 00		
	...	8 3)	17	17 00	31	.548	...		
	9 30	11 10)	24	11 10	24	.465	1 30	1 30	Rock in teeth
	...	...	..	...	..	..	...	3 30	Car off track
Total	141 35	296 40	709	296 40	709		41 20	128 00	
Average	6 26.1	19 01		12 53.6	30.82	.421	3 13⅓		

Trains loaded, 16; moves worked, 23; total cars loaded, 156.
First and last trains, 8 cars each; others, 10 cars.
* Not included in average.

SHOVEL No. 517

TIME OF DIFFERENT PARTS OF DIPPER ACTION

	TABLE No. 1			TABLE No. 2			
	Digging Seconds	Swinging Over Seconds	Swinging Back Seconds	Scratching Seconds	Digging Seconds	Swinging Over Seconds	Swinging Back Seconds
. .	6.0	6.4	7.6	5.6	9.8	4.8	7.2
. .	4.8	4.4	7.2	5.6	9.0	5.6	7.2
.	4.4	5.6	8.0	5.4	10.0	6.2	8.0
. .	8.0	5.6	7.4	4.8	9.6	(12.6)	8.4
. .	6.4	6.4	7.0	. .	(6.0)	4.2	7.4
. .	8.4	7.2	6.2	6.0	10.6	5.4	7.8
. .	5.4	6.2	7.6	8.0	7.6	(10.8)	(12.2)
. .	6.4	. .	. .	5.0	9.0	6.0	7.2
. .	3.6	5.6	9.4	5.2	9.2	4.6	7.2
. .	7.0	7.2	7.8	. .	(5.2)	4.0	9.6
(8.0)	(8.0)	5.8	7.6	5.6	8.0	5.0	. .
(8.0)	(8.0)	6.2	8.4	. .	(4.0)	5.6	7.2
4.8	8.4	6.6	9.0	6.8	10.6	5.2	(10.0)
. .	4.4	6.2	6.8	. .	(6.0)	7.8	9.2
. .	4.8	4.8	(14.0)	. .	(4.8)	5.4	8.8
6.4	7.2	7.0	. .	5.6	11.4	6.6	7.4
. .	6.0	4.0	6.4	6.4	10.4	6.4	7.8
5.8	8.2	. .	. .	5.0	9.2	6.8	9.0
. .	5.2	5.2	9.2	7.2	7.8	7.2	6.8
(6.8)	(7.0)	6.2	6.6	. .	(5.0)	6.8	8.0
(6.8)	(7.0)	6.4	6.8	5.0	9.6	8.0	7.4
. .	6.8	6.2	2.8	5.8	8.8	7.4	8.0
.	(10.4)	4.2	7.2	6.0	8.2	7.2	8.4
8.2	9.6	5.2	8.0	. .	6.2	8.0	(12.8)
(8.2)	(8.2)	5.2	6.4	4.8	7.6	6.8	
(6.4)	(6.6)	6.0	9.6				
. .	7.2	7.0	6.8				
. .	5.2	4.8	8.4				
(7.6)	(7.6)	6.4	7.2				
. .	4.8	6.4	8.2				
. .	5.8	6.2	. .				
. .	5.6	7.0	9.0				
. .	5.6	5.6	6.4				
. .	8.0	4.8	8.6				
(7.4)	(7.6)	6.0	5.6				
. .	7.2	4.8	8.0				
(7.6)	7.8	4.6	7.8				
(8.1)	(8.1)	4.4	7.6				
(6.8)	(7.0)	4.8	8.0				
Total . .	168.2	212.6	254.6	103.8	172.6	141	158.0
Trials . .	28	37	34	18	19	23	20
Average .	6.00	5.74	7.49	5.76	9.08 (5.10)	6.13	7.90

Fig. 32. Type of Dump Car used at Grant Mine, Buhl, Minn.

Fig. 33. View of Grant Mine, Buhl, Minn.

REPORT No. 20 — SHOVEL No. 727

INSPECTED AUGUST 26, 1909

CHICAGO, ILL.

LOCATION Bucyrus Steam Shovel No. 727, owned by the American Brick Company, is located in one of its clay pits near 45th and Roby Streets, Chicago, Ill.

SHOVEL AND CREW The machine was purchased from the factory about five years ago and has been used continuously since then to excavate clay. No itemized list of the repairs has been kept, but they have been slight, not amounting to over $350. It is provided with a chain hoist and cable swing, each being operated by a separate steam engine. The friction ram which operates the hoist is worked by hand and not by steam, as on some of the larger machines.

The crew is composed of four men, the engineer, who is also fireman, the craneman and two pitmen. The pitmen keep the dinkey track clear and lay the ties and rails for the shovel to move upon.

MATERIAL The pit is very soft and sticky in wet weather, but when it is dry is not unpleasant to work in. There is some sand mixed with the clay but not enough to cause trouble when they are loaded together.

SUPPLIES Coal is brought out in one of the clay cars and shoveled into a box on the ground since the cars dump on the side away from the shovel. Water is supplied to the tank through a pipe connecting with the city mains.

TRANSPORTATION One dinkey hauls the cars back and forth from the shovel to the incline, where they are drawn up to the granulator by a wire cable connected to a steam driven drum. The man who runs the engine also dumps the cars. Two cars generally constitute a train, but occasionally there are three. The haul to the bottom of the incline is about four hundred feet. One man is stationed at the botton to hook on the cars. The dinkey engineer does his own firing. The cars weigh about a ton and a half and hold 3.12 cubic yards. The shovel could work considerably faster if the machinery could use the clay, but often a car is drawn to the granulator and held there for several minutes before it is dumped, and as very large chunks of clay can not be easily handled in the granulator the engineer must so run the shovel as to shave off the bank, which, greatly retards the speed of loading. There is a switch at a little distance from the foot of the incline where the track divides, coming together again half way up the slope. The loaded cars are run in on the right track of this switch and the empties are hauled out from the other side. Since the switches all work automatically by springs the dinkey cannot pull out of the switch and back in to get the empties, so a cross over is provided

OBSERVATIONS

Weight	55 tons
Gauge	Standard
Capacity of dipper	2 cubic yards
Height of lift	5′
Kind of teeth	Manganese steel
Height blocked up	1′
Length of boom	25′
Length of dipper handle	16′ 6″
Height of boom above shovel track	22½′
Horizontal reach of boom	17′ 10″
Farthest dipper can reach to dump	25′

OBSERVATIONS—*Continued*

Highest dipper can reach to dump	15′
Diameter of swing circle	6½′
Height of dinkey track above shovel track	0
Distance inside dinkey track to inside shovel track	15′
Depth of dipper	46″
Depth of dipper, including lip	58″
Depth of dipper, including teeth	72″
Number of cars loaded	160
Cubic yards excavated (place measure)	320
Total distance moved forward during day	19′
Number of times moved forward	4
Maximum distance moved forward in one move	5′ 2″
Average time between beginning of one shovel move and beginning of next	118 minutes
Number of cars to one shovel move	42.7
Area of section	500 square feet
Height of face	22′

TIME STUDY

	Forenoon	Afternoon
Started work	6:45	12:57
Stopped work	12:00	3:52

Total time worked 315 Min. + 175 Min. = 490 Min. = 8 hours 10 minutes.

	Minutes	Seconds	Per Cent
Actual working	140	00	28.6
Spotting cars	5	00	1.0
Waiting for cars	295	30	60.3
Moving shovel	16	30	3.4
Idle			
Car off track	20	00	4.1
Firing	1	00	0.2
Bringing out coal	1	00	0.2
Miscellaneous delays			
Clearing track	11	00	2.2
Total time under observation	490	00	100.00

Direct Labor Distribution Per Day	Standard Basis			
	Loading	Transporting	Dumping	Total
Runner	$5.00	...	...	...
Craneman	3.60	...	...	...
2 pitmen	3.00	...	...	...
Dinkeyman	...	$2.60	...	...
Hooker-on	...	1.50	...	...
1 dumpman	...	...	$1.50	...
Cost of labor per day	$11.60	$4.10	$1.50	$17.20
Cost per day per cubic yard	3.62	1.28	0.47	5.37
Per cent	67.4	23.8	8.8	100.0

Process Analysis	Time		Per Cent	Cost Per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Loading					
1. Actual loading	140	00	28.6	1 035	1.172
2. Delays					
a Moving up	16	30	3.4	0.123	
b Miscellaneous	2		0.4	0.014	
Transportation and dumping					
1. Waiting for cars	300	30	61.3	2.220	2.448
2. Miscellaneous	31		6.3	0.228	
	490	00	100.0	...	3 620

Figs. 34 and 35. 55-ton Shovel in Clay Pit of American Brick Co., Chicago, Ill

CHAPTER VIII

STEAM SHOVEL WORK IN IRON ORE

Very unusual efficiency is shown by the investigation of the work done in the iron ore regions of Michigan and Minnesota. There seem to be the following reasons for this: 1. The work is largely in the nature of a permanent installation, and consequently years of study on one job have developed an efficiency that a contractor is not likely to attain on one comparatively short piece of work with uniform conditions, or on many jobs with varying conditions; 2. The material is generally quite uniform, and presents month after month and year after year fewer new and strange conditions than does the average run of rock work, therefore the problem is simpler; 3. It appears that the companies operating in this region for some reason are in the habit of studying their unit costs more systematically than the average contractor's organization. Study of these costs invariably leads to more economical work, wherever we have observed them.

It is the general policy of the mining companies not to give out any information from their books, and, therefore, much instructive data on cost of repairs, etc., could not be obtained from them, but they have extended the courtesy of allowing our inspectors to make observations in the field very freely.

The notable feature in ore handling is its great density, involving a much greater amount of power to raise a cubic yard, than in the case of the earths.

MESABI RANGE

In St. Louis County, Minnesota, some thousand feet above the level of Lake Superior, is located one of the most remarkable iron ore regions in the world, due

directly to the geological formation, and, indirectly arising from this to the method of excavating the ore which has been extensively adopted. Beneath the bases of the huge mountain ranges of past ages, which millions of years of the slow but incessant action of the natural elements, frosts, floods and great fields of ice have gradually ground down to a nearly uniform surface, are found the great beds of red and black iron oxide of the Mesabi Range. The soluble alkalis and silica cement of old bed rock, an unstable iron silicate locally known as taconite, have been slowly worn away by centuries of constant water action, until now the vast disintegrated deposits extend for miles, covered by a mantle of drift material, gravel and boulders varying in depth from 0 to 90 feet or more, and in some spots rise up through the surface. The range is about 100 miles in length and from one-half to three miles wide, covering an expanse of 150 miles, or thereabouts, of which 15 per cent to 30 per cent is capable of producing an iron ore whose quality is unsurpassed, even by the best products of the old world. The beds average in depth from 75 feet to 250 feet, but have been known to extend down 500 feet and 600 feet. Thus it is seen that these wonderful deposits embody all of the requisites for ideal ore mining, not only in quality and quantity of product, but ease and facility of handling. This feature opened the way for a new method of excavation, one far superior to the old, that of the steam shovel. Unknown in mining work twenty years ago, this method, which enables the output of the Mesabi district to surpass that of any other region of the world, has done much toward making the United States the foremost iron and steel producing country of to-day. The location of these mines places their product within easy reach of the principal inland cities and ports, thus making them an ideal distributive center for this country. Contributing to this valuable and bountiful supply

are more than one hundred mines in active operation. According to the inspector of mines of St. Louis county, the output of various mines for the fiscal year ending June 30, 1909, was as follows: Hull Rust, 3,266,905 tons; Fayal, 1,660,919 tons; Burt, 1,595,435 tons; Virginia, 1,181,726 tons; Adams, 1,176,330 tons; Mahoning, 1,064,611 tons. The supply promises to hold out for many decades, both from the output of the mines operated at present, as well as from those which are continually being discovered and put into operation.

When a new mine is to be opened, in the first place an "exploration company" is employed to locate, as nearly as possible by drilling, the position and shape of the deposit, to map it out, to estimate the probable productive capacity and the amount of "stripping" necessary. This latter, which consists of removing the overburden of drift with the steam shovels, after clearing of timber, etc., is usually done by contract. This overburden varies from a glacial till, easily handled, to coarse gravel, clay, boulders, low grade ore, etc., frequently requiring to be loosened by blasting. It is the usual practice to strip enough ore to enable the mining to be started, and then to strip and mine simultaneously, but occasionally the stripping is entirely completed before the mining proper begins. The steam shovel is placed upon a portable track. Upon a parallel one, close by, automatic dump cars from four to seven cubic yards in capacity, in trains of seven to ten cars each, are run alongside by a dinkey engine, and when filled by the shovel are hauled to the dump, usually from one-eighth to one and one-half miles distant from the mine.

Although contracts are made for both stripping and mining, the latter is usually performed by mining companies. The process is practically the same as that of stripping, the cars in this case, however, being of about fifty tons capacity. The railroad furnishes the cars and takes them in charge at the entrance to the mine; all

other equipment is owned by the mining company, and the spotting of the cars for the shovel and all transportation in the mine is done by them. The shovel ordinarily employed weighs from 65 to 90 tons, though larger ones are used, and will handle from two to five tons of ore at each swing of its dipper.

Although the method of "open-pit" mining described above is the most economical and productive, as well as the one most extensively practiced in this region, others are employed, such as the "milling," and the old universally known "underground" methods. In the "milling" process a shaft is sunk close beside the ore bed to a depth sufficient to allow a tunnel to branch off beneath the deposit. After "stripping," a funnel-shaped opening is made through the bed and down to the tunnel. The ore is fed or "milled" down this opening into tram cars, which in turn convey the ore through the tunnel to the shaft, where skips raise it to the surface. During the summer the skips dump into bins from which the ore is loaded directly into the railway company's cars, but in the winter season stock piles are formed from which the steam shovel loads the ore the following summer.

Fig. 36. Hull-Rust Mine, Oliver Iron Mining Co., Hibbing, Minn.
Largest Producing Mine in the World. Output for Fiscal Year Ending June 30, 1909, 3,266,905 Tons

Fig 37. Pool-Burt Mine, Hibbing, Minn. Output for Fiscal Year Ending June 30, 1909, 1,595,435 Tons (Burt)

Fig. 38. Mahoning Mine, Hibbing, Minn. Output for Fiscal Year Ending June 30, 1909, 1,064,611 Tons

Fig. 39. Sellers Mine, Hibbing, Minn.

Fig. 40. Leonard Mine, Chisholm, Minn.

Fig. 41. Chisholm Clark Mine, Chisholm, Minn.

Fig. 42. Sliver Mine, Virginia, Minn.

Fig. 43. Higgins Mine, Virginia, Minn.

Fig. 44. Pillsbury Mine, O. I. M. Co., Chisholm, Minn.

Fig. 45. Illustration Showing Self-sharpening Wear on Teeth at Hanna Mine

Fig. 46. Monroe Pit at Chisholm, Minn.

GENERAL REMARKS

OLIVER IRON MINING COMPANY

HIBBING, MINN.

GAUGE Many of the companies use standard gauge equipment entirely and this simplifies their work immensely; for instance, if necessary, the loading track can be broken behind the shovel and the shovel moved back on that track at any time. Generally, however, a standard gauge track is laid keeping within 40 or 60 feet of it and when the shovel has finished a cut it backs up on this track, which at once becomes the loading track for the next shovel cut.

REPAIRS In case heavy repairs are to be made on a shovel a locomotive crane is run in on the loading track and the work done with its help. A locomotive crane is kept in the Hull-Rust mine at all times and is used as a wrecking outfit when needed in addition to its use on shovel repairs.

TEETH In the stripping, as done in the Sellers' Approach, the teeth on the dipper have to be renewed at least once a week and this is generally done every Sunday. It sometimes becomes necessary to replace a single tooth or perhaps two of them during the week, but each shovel is supposed to use 4 teeth per week and this average holds as a general rule. In ore the teeth are supposed to last a month. They are never broken and seldom bent and all wear down evenly. They wear from the outside or the bottom, as one craneman expressed it, and so keep themselves sharpened. They are allowed to wear down within about 6 inches of the lip and the short blunt teeth thus obtained seem to make no difference in the digging.

TRANSPORTING The cars used for earth are of the seven yard side-dump type. For ore the one most commonly used is the 100,000-pound pressed steel hopper car, although there are still in use many 70,000-pound capacity wood cars, hopper bottom. Both types are M. C. B. standard equipment throughout. The hopper doors are worked by a hand crank. The steel cars have, in general, a height of 10 feet from rail and the wood cars 7 feet 6 inches. This equipment belongs to the railroad company that carries the ore to the loading docks. The stripping equipment is the property of the mining company or the contractor, as the case may be. All hauling within the mines is done by the mining companies' locomotives, the railroad companies merely placing the empties on the mine siding, as they would for any other shipper.

SHOVEL CREW For stripping, the shovel crew is the usual organization with 4 or 6 pitmen, varying with the nature of the work. The number is generally 4, with 2 extra men to clear track. These two men are called "rock men" and are used in the pit only in case of emergency. When loading ore the pit crew is always 4 and the rock men may number as many as 8. The rock gang varies according to the nature of the ore being loaded. If the ore breaks out in large pieces it has to be sledged, and if taconite occur this must be removed. On No. 1083 there were 6 rock men in the pit and two in the cars throwing out rock and suspicious looking ore.

ORE REQUIREMENTS The shipping requirements for ore affect the output of a mine very largely and consequently the working of the shovels. In order to produce ore of a certain grade for shipment, that from several mines is often

mixed. For instance, if the ore of one mine should run .05 in phosphorous, it may be mixed with the ore from another mine running .02 and be in such proportions that the shipment will pass as Bessemer grade. In this way one mine may be rushed to fill orders for shipment while another is almost idle.

LOADING All pieces of rock or taconite too large to lift by hand and too hard to break are thrown by the shovel as far back as possible and left. The pieces that the men can handle are thrown down near the loading track at the foot of the bank to be loaded later. This loading is done as follows: Several dump cars are left at each shovel. When a train arrives to be loaded these cars are coupled to the front end of it and pushed along with the train. When loaded, the train spots the dump cars at the shovel and pulls out, leaving them there. The shovel then picks up what it can of the pile of rock by the loading track and what it cannot get hold of readily is thrown into the dipper by hand. This is then dumped into the cars. When the next ore train arrives it simply pushes the dump cars out of the way, loads and again spots the cars and pulls out. When rock is loaded into the cars with the ore there is sometimes a slight delay when the two workmen on the cars jump down to pick it out. If there is much of it, or if it has to be sledged, the loading must be stopped while the men finish their work and get out of the way. In such cases the full dipper is held just clear of the car, while the men move aside, immediately after which the swing is completed. This delay does not amount to much for each swing, since it is only a few seconds long, but if much rock should be loaded with the ore the delay might amount to several dippers full per day.

GENERAL Work is seldom stopped by rain and it may be said that during the shipping season the loading of ore is never interrupted because of the weather. Of course, an occasional shower of great severity might cause temporary suspension of work, but the crew would not leave the shovel for such cause. The mines are comparatively dry until the bottom of the ore is reached, as water goes through it easily, and all of the deep pits are underdrained by means of shafts sunk in them and kept dry by pumps.

REPORT No. 21 — SHOVEL No. 710

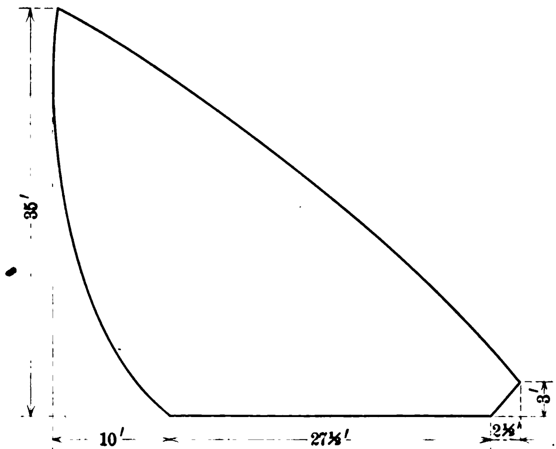
INSPECTED SEPTEMBER 5, 1909

CHISHOLM, MINN.

MATERIAL Shovel No. 710 was engaged in stock pile work for the Oliver Iron Mining Company. The stock pile had been accumulating for two years and was some 35 feet high. It was about as ideal a material to work in as could be desired. Two shafts of the Monroe mine furnished the ore for the stock pile. Some trouble was caused by piles of lagging that fell down in front of the dipper. This had been used to make a solid base for the end dump cars to run upon. The ore was soft and in small pieces. There was no frost and a full dipper was obtained at each swing. It might be expected that with such a high pile there would be trouble due to burying of the jack, but here the cave-in always occurred ahead of the dipper and caused no trouble.

PERFORMANCE A very good morning's work was observed, fifty-eight cars in all, forty-nine being 50-ton steel cars and nine 35-ton wooden cars. The afternoon's work was delayed by one of the

large steel cars getting off the track. It was loaded, and nothing could be done until the section gang came up. Meanwhile the string of empties was taken out and no more work was done that afternoon.



Cross-section of Bank

OBSERVATIONS

Type of shovel . . . . Bucyrus, 90-ton
Distance of move . . . . 6′
Kind of teeth . . . . Steel lip
Height of lift, steel cars 12′; wood cars, 10′ 4″; size of ties, 6″ x 8″, and 5″ x 7″.
Size of bucket . . . . 2½ yards
Age of shovel . . . . 4½ years
Duration of job: will last only until present cut is finished; time, about two weeks.
Length of shift . . . . 10 hours
Number of shifts per day 1

OBSERVATIONS—*Continued*

How supplies are handled (coal and water): Coal is brought up by team and shoveled into bunkers. Water pumped from tank.

How and when repairs are made: Repairs made on Sunday by regular crew.

Coal used . . . . $4\frac{1}{2}$ tons in 10 hours

Oil used . . . . Black, 5 gallons in 10 hours.
Engine, 1 gallon in 10 hours.
Cylinder, 2 gallons in 10 hours.
Cup grease, 5 gallons in two weeks.

Water used . . . . 7700 gallons in 10 hours

Boiler is cleaned every second Sunday.

Number of working and rainy days: Weather did not make as much difference as car supply. Total per cent of lost and idle days not obtainable.

Kind of track, i. e., gauge, etc.: Standard gauge, 60-pound.

Kind and size of cars used: Steel, 50-ton capacity. Wooden, 35-ton capacity.

Steel cars: U. S. Standard Pressed Steel Car Company; Pressed Steel Car Company.

Wooden cars: American Car & Foundry Company; Pullman Company.

How train is braked: By air, hand signals.

Kind and size of dinkey: Standard locomotive about 60-ton.

Length of haul varies, but around 2000′.

Number of trains 1

Weather, clear and cool.

Shovel has swing jacks.

Moved forward . . . . 36′ during day

Hoist engine cylinders . . . . 14″ x 16″

Swing engine and crane engine . . . . 9″ x 9″

Side cut.

Dipper of larger capacity might easily be used. Cut dry and clean.

TIME STUDY

	Forenoon	Afternoon
Started work	7:00:00	1:00:00
Stopped work	12:00:00	2:42:05

	Min.	Min. Sec.	
Total time worked 5 seconds.	300 +	102 5	= 6 hours 42 minutes

	Minutes	Seconds	Per Cent
Actual working	278	40	69.3
Waiting for cars	77	35	19.3
Moving shovel	27	5	6.7
Miscellaneous delays			
Picking lagging out of pit .	8	30	2.1
Fixing block for wheels . .	3	..	0.7
Oiling (3 men)	5	..	1.3
Other delays	2	15	0.6
Total time under observation .	402	5	100.0

Cost of Direct Labor (Loading) Per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
1 trimmer	1.50
	$21.50

Number of carloads excavated on day of observation, sixty-four 50-ton and thirteen 35-ton = 3655 tons.

Based on the observed performance, the number of tons excavated per 10-hour day $3655 \times \dfrac{600 \text{ minutes}}{402 \text{ minutes } 5 \text{ seconds}} =$ 5455.

Number of cubic yards excavated per 10-hour day (2 tons per yard) 2728.

Cost of direct labor per day, per cubic yard $= \dfrac{\$21.50}{2728} = 0.79$ cents per cubic yard.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loading					
1. Actual loading . .	278	40	69.3	0.548	0.638
2. Delays					
a Moving up . . .	27	5	6.7	0.053	
b Miscellaneous . .	18	45	4.7	0.037	
Charge to transporting					
Waiting for cars . . .	77	35	19.3	0.152	0.152
	402	5	100.0	. . .	0.790

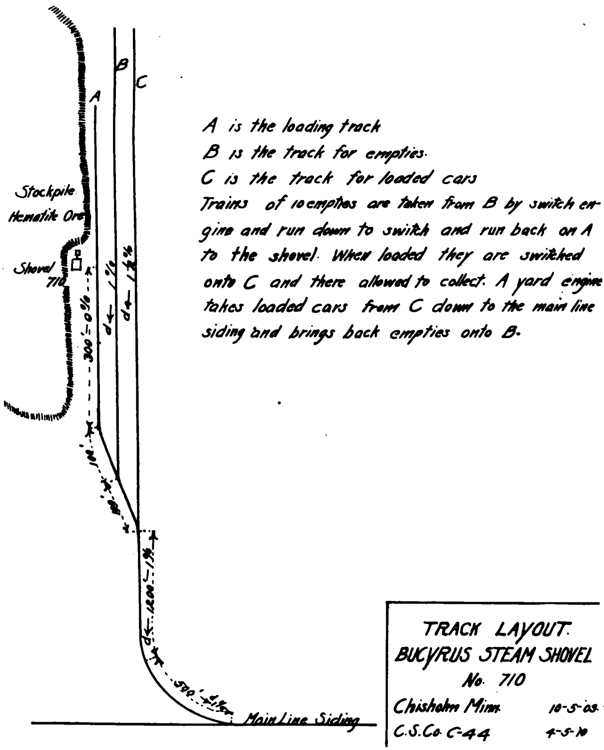
ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{64{,}150}{9{,}000} = 7.12.$$

Time Study Deductions	Number of Observations	Minimum Min.	Minimum Sec.	Average Min.	Average Sec.	Maximum Min.	Maximum Sec.
Time of moving up, shovel idle	6	2	35	4	31	7	50
Time between moves, shovel working	6	18	5	46	27	77	40
Time between trains	7	6	35	10	16	14	10
Time per train, loading	10	8	30	27	52	42	0
Time per dipper	5	..	21.2	..	22.4	..	24.4
Number of dippers per move	6	51		117.5		205	
Number of dippers per train	10	24		72		97	
Number of dippers per car	..	..		9.35		..	

Number of trains loaded 10
Number of cars loaded 77

	Train Number	Steel Cars	Wood Cars
Cars per train	1	8	2
	2	7	3
	3	8	2
	4	2	1
	5	10	0
	6	9	1
	7	5	0
	8	6	3
	9	5	0
	10	4	1
Total	..	64	13



A
B
C
Stockpile
Hematite Ore
Shovel
710
A is the loading track
B is the track for empties.
C is the track for loaded cars
Trains of 10 empties are taken from B by switch engine and run down to switch and run back on A to the shovel. When loaded they are switched onto C and there allowed to collect. A yard engine takes loaded cars from C down to the main line siding and brings back empties onto B.
Main Line Siding
TRACK LAYOUT.
BUCYRUS STEAM SHOVEL
No. 710
Chisholm Minn. 10-5-09
C.S.Co. C-44 4-5-10

Figs. 47 and 48. 90-ton Bucyrus Shovel at Work on Stock Pile of Oliver Mining Company, Chisholm, Minn.

REPORT No. 22 — SHOVEL No. 719

INSPECTED AUGUST 7 AND 8, 1909

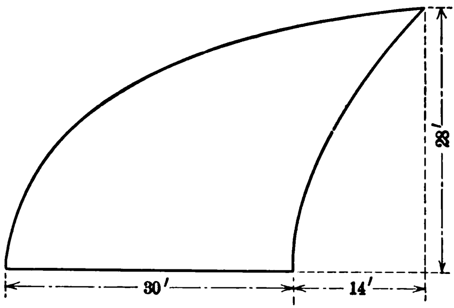
AMASA, MICH.

LOCATION Shovel No. 719 belongs to the Verona Iron Mining Company, of Stambaugh, Mich. At the time of this investigation the shovel had been leased to the Iron Mining Company, at Amasa, for the purpose of cleaning up the stock pile at that place. Runner, craneman and fireman went with shovel.

SHOVEL It took one day to set up the shovel after its journey from Stambaugh, and another half day to put on a new lip. The usual style of "lip" employed in stock pile work is of manganese steel. But the one that had been ordered for this shovel did not fit, and so an ordinary mild steel lip, minus the teeth, was attached. The boom of this shovel was supported by two cables instead of the customary eye-bars.

MATERIAL The ore in the stock pile was soft, without frost, and furnished very easy digging. The posts used in forming the trestle work were pulled up by the shovel by means of a chain wrapped around the pole and secured to the dipper, and afterward swung in alongside the shovel. Usually these poles could be removed between trains and so cause no extra delay. Three and a half minutes was the observed time for one of these operations. Because the ore was slightly undercut, one man was kept on the pile with a pick to loosen the bank and so prevent the jack from becoming buried after the shovel moved forward. This man also manipulated the chain used in the removal of the posts. Between trains, when not pulling posts, the

runner would "claw" in toward the main pile as much of the ore lying near the loading track as possible. Whatever ore the runner could not thus handle was shoveled into the dipper by the pitmen. In this way a clean trail was left by the shovel and very little ore wasted.



Typical Cross-section

OBSERVATIONS

Type of shovel	70 C
Distance of move	6′
Kind of teeth	Bucyrus lip minus the teeth
Height of lift	9½′

Size of ties under shovel, 6″ x 8″. Ties had arrangement for slipping in rail as before described (see Fig. 51) on 1106.

Size of bucket	2½ yards
Age of shovel	Fifth season
Duration of job	At Amasa, Mich., 9 days
Length of shift	10 hours
Number of shifts per day	1

Coal is brought by team and shoveled out of the wagon into the bunker. Distance about 200 yards.

Repairs small, and made while waiting for cars.

Coal used	2½ tons per day of 10 hours
Oil used	0.78 gallon in 1 day (black) 0.44 gallon in 1 day (cylinder) 0.22 gallon in 1 day (kerosene)

OBSERVATIONS—*Continued*

Water used . No record, but about 3500 gallons in 10 hours
Boiler is cleaned once a week while waiting for cars.
Kind of track, weight of rail, gauge, etc. Standard gauge, 50-pound rail.
Kind and size of cars used. Cars, 40 tons capacity; weight, 37.5 tons; estimate by maker; kind, wooden.
The train is braked by air.
Kind and size of dinkey. One switch engine, American locomotive about 40 tons; one line engine to bring in empties. Saturday, August 7, shovel began working after luncheon at 1:30 and worked until 3:31:20, when cars gave out and no more until the 8th.
Weather, raining almost all day Aug. 8.

NOTE.—The shovel had been brought over to Amasa from Stambaugh. It had been at Amasa 9 days. The office gave the following data:

Shovel at Amasa . 9 days; excavated 17,850 tons
Actual hours worked . . . . 59 hours

Delays due to setting up shovel, taking off old lip and putting on new, and waiting for cars to come to mine. (Do not include time between trains).

Delays	Setting up .	1 day
	New lip . .	½ day
	No cars . .	1½ days

TIME STUDY

	Forenoon	Afternoon
Started work	9:37:5	(1:04:15) (1:30:00)
Stopped work	12:01:00	(5:30:40) (3:31:20)

Total time under observation 143 min. 55 sec. + 266 min. 25 sec. + 121 min. 20 sec. = 8 hours 51 minutes 40 seconds.

	Minutes	Seconds	Per Cent
Actual working	310	26	58.4
Waiting for cars	154	19	29.0
Moving shovel	63	20	11.9
Miscellaneous delays . . .	3	35	0.7
Total time under observation	531	40	100.0

Cost of Direct Labor (Loading) Per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6.00
	$17.00

Number of tons excavated per day (average of 6 days) 3000 tons.
Number of cubic yards loaded per day (average of 6 days, 2 tons per yard,) 1500.

$$\frac{\text{Cost of labor per day}}{\text{Number of cubic yds. per day}} = \frac{\$17.00}{1500} = 1.13 \text{ cents per cubic yd.}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost in Cents per Yard	Total Cost Cents
Charge to loading					
1. Actual loading	310	26	58.4	0.660	0.802
2. Delays					
a Moving up	63	20	11 9	0.134	
b Miscellaneous	3	35	0 7	0.008	
Charge to transportation and dumping					
1. Waiting for trains	154	19	29.0	0.328	0.328
	531	40	100.0		1.130

TIME STUDY DEDUCTIONS

	Number of Observations	Minimum Min.	Minimum Sec.	Average Min.	Average Sec.	Maximum Min.	Maximum Sec.
Time of moving up, shovel idle	10	5	0	6	20	7	50
Time between moves, shovel working	10	21	18	31	3	41	25
Time between trains	13	3	40	11	52	27	45
Time per train, loading	16	10	10	19	24	35	30
Time per dipper	10		20.6		23 9		28.9
No. of dippers per move	10	61		77.9		99	
No. of dippers per train	16	29		48.7		65	
No. of dippers per car				9.74			

Number of trains loaded		16
Number of cars loaded		80
Number of cars per train		14 trains of 5 cars each. 1 train of 7 cars. 1 train of 3 cars.

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{29{,}160}{5000} = 5.83$$

Fig. 49. "Clawing" between trains

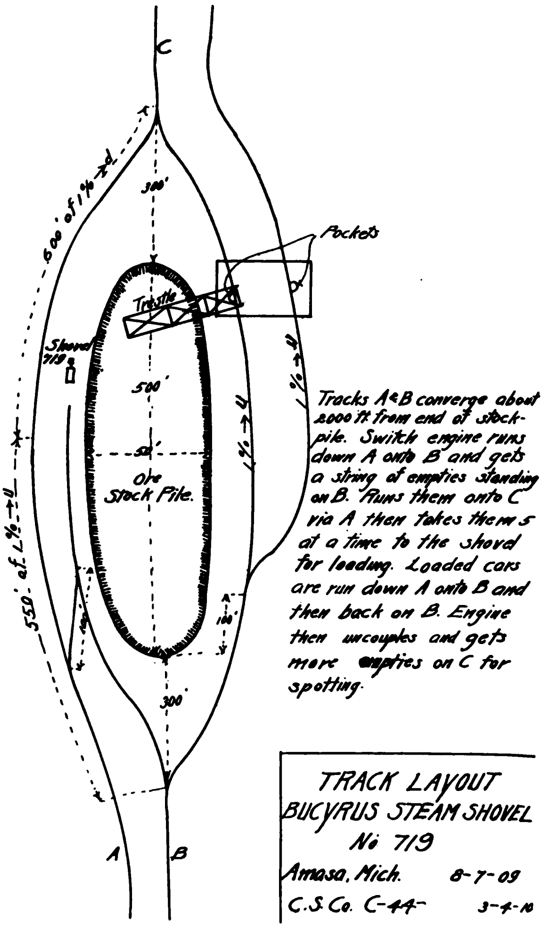

C
300'
600' of 1% ↑ ↓ d.
Pockets
Trestle
Shovel 719
500'
50'
Ore Stock Pile.
1% ↑ ↓
550' at 1% ↑ ↓
100'
300'
A
B
Tracks A & B converge about 2000 ft from end of stock-pile. Switch engine runs down A onto B and gets a string of empties standing on B. Runs them onto C via A then takes them 5 at a time to the shovel for loading. Loaded cars are run down A onto B and then back on B. Engine then uncouples and gets more empties on C for spotting.
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No 719
Amasa, Mich. 8-7-09
C.S. Co. C-44- 3-4-10

Fig. 50. Method of Chucking Shovel

Fig. 51. View Showing Method of Removing Old Trestle Post from Stock Pile
(See page 198)

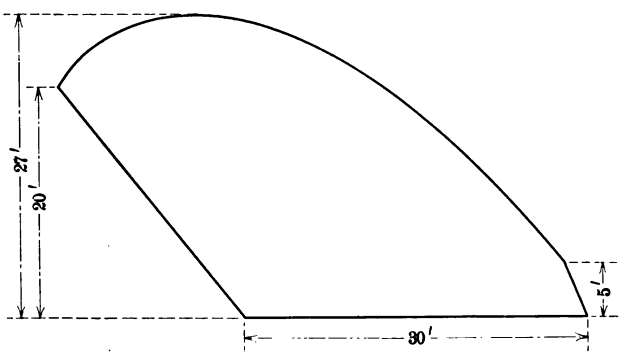
REPORT No. 23 — SHOVEL No. 707

INSPECTED JULY 27, 1909

NEGAUNEE, MICH.

GENERAL CONDITIONS This shovel belongs to the Cleveland Cliffs Iron Mining Company, and at the time of this investigation was engaged in stock pile work at the Negaunee mine.

MATERIAL The ore was badly frozen in spots, making very tough digging. It was so hard several times that the runner threatened to stop work until the ore could be blasted. As is usually the case, the ore had been stocked on planking. In the Maas mine about a mile distance, and operated by the same company, a 65-ton shovel was used in similar stock pile work. The shovel crew worked part of the time on one shovel and part on the other, according to the grade of ore needed.



Typical Cross-section of Bank

TRANSPORTATION One engine spotted the cars and also pulled them out to the main line siding after loading. It is the common practice for the engine to bring in a certain number of cars, and, after loading, to take out the same number. But here, probably on account of the steep grade shown in "track lay out," trains were broken and two or three loaded cars taken out at a time.

OBSERVATIONS

Type shovel	Bucyrus, 70-ton
Distance of move	5′
Kind of teeth	Manganese lip
Lift	10′ high
Size of ties under shovel	6″ x 8″

Number of buckets to car and to each move: 12 dippers to each 50-ton car; about 7 dippers to each 30-ton wood car.

Shovel in use 4½ years.

Job started June, 1909.

Shift, 10 hours.

One shift per day.

Water is pumped from boiler house, in a pipe which terminates in a flexible rubber hose, a distance of 200 yards. Coal is drawn up to shovel in a wagon and shoveled directly into hopper.

Coal used	1½ to 2 tons in 10 hours
Oil used	Valve, 2⅔ quarts 10 hours Black, 1¾ quarts 10 hours Engine, 1½ quarts 10 hours
Water used	About 3000 gallons in 10 hours

Boiler is cleaned every fourth Sunday.

Kind of track, i. e., weight of rails, gauge, etc.: Standard gauge; 50-pound rail.

Kind and size of cars used: Steel, 50 tons, Pressed Steel Car Company; wooden, 30 tons, L. S. and I. R. R.

Train is braked by air. Hand signals used.

Kind and size of dinkey: Pittsburg locomotive, 1896, 65 tons. No other spotting engine than one mentioned.

Weather, clear and warm.

TIME STUDY

	Forenoon	Afternoon
Started work	10:37:00	12:36:15
Stopped work	11:36:15	4:57:30

		Min.	Sec.		Min.	Sec.		
Total time worked	=	59	15	+	261	15	=	5 hours

20 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	148	2	46.2
Waiting for cars	139	18	43.5
Moving shovel	25	20	7.9
Miscellaneous delays . . .	7	50	2.4
Total time under observation .	320	30	100

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
	$20.00

Number of cars loaded on day of observation, 46, at average of 40 tons.

Cubic yards loaded on day of observation (2 tons per cubic yard) = $\frac{46 \times 40}{2} = 920$.

Based upon the observed performance the cubic yards loaded per 10-hour day $= \frac{920 \times 600}{320\frac{1}{2}} = 1720$

$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$20.00}{1720} = 1.16$ cents per cubic yard

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loading					
1. Actual loading . .	148	2	46.2	0.536	0.656
2. Delays					
a Moving up . . .	25	20	7.9	0.092	
b Miscellaneous .	7	50	2.4	0.028	
Charge to transporting					
1. Waiting for cars .	139	18	43.5	0.504	0.504
	320	30	100.0	. . .	1.160

TIME STUDY DEDUCTIONS

	Number of Observations	Minimum		Average		Maximum	
		Min	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	7	2	45	3	37	4	50
Time between moves, shovel working .	5	23	55	25	55	30	50
Time between trains	9	3	5	8	31	16	20
Time per train, loading *							
Time per dipper . .	7	..	20.5	..	24.1	..	28.9
Number of dippers per move . . .	5	54		63		72	
Average number of tons per dipper .	.	..		5.03		..	

* Time per train could not be obtained owing to the erratic nature of the engine's work.

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{25{,}000}{3{,}000 \text{ to } 4{,}000} = 8.33 \text{ to } 6.25$$

CLEVELAND-CLIFFS IRON COMPANY.

NEGAUNEE MINE **STEAM SHOVEL REPORT.**

No. 7

Form 125-1M-4-07- I.O.

_______________ 190__

TIME SPENT (HOURS)			WHERE WORKING	NUMBER OF CARS LOADED	NUMBER OF TONS	GRADE OF ORE	KIND OF CARS	NO. OF MEN
WORKING	DELAYS	IDLE						

CAUSE OF DELAY	TIME OF DELAY		TIME LOST	
	FROM	TO	MINUTES	HOURS
Waiting for cars				
Waiting for engine				
Moving Shovel				
Track work				
Shovel repairs				
Switching				

Remarks: ____

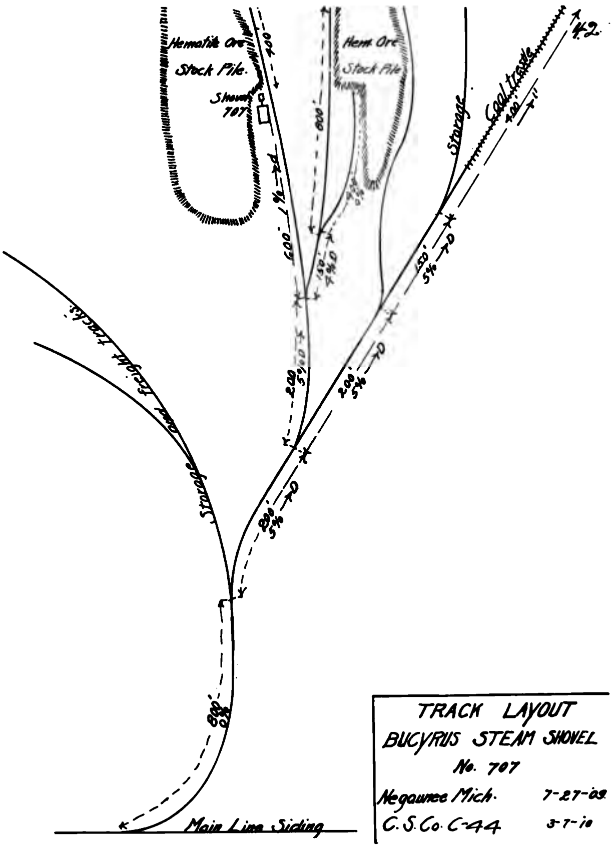
____

____

____

____________________________ **Engineer.**

Report must be sent to office PROMPTLY every morning.
All delays and time lost must be accurately reported.


Hematite Ore
Stock Pile
Shovel
707
Hem. Ore
Stock Pile
Storage
Coal trestle
42
and Freight tracks
Storage
Main Line Siding
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No. 707
Negaunee Mich. 7-27-09
C. S. Co. C-44 3-7-10

Figs. 52 and 53. 70-ton Bucyrus Shovel at Work on Stock Pile of Cleveland Cliffs Iron Company, Negaunee, Mich.

REPORT No. 24 — SHOVEL No. 1127

INSPECTED SEPTEMBER 10 AND 11, 1909

IRONWOOD, MICH.

MATERIAL This shovel, a 70C, was engaged in Hematite ore stock pile work. The function of the so-called "stock pile" is to keep the mine running at its full capacity the year round.

GENERAL CONDITIONS During the navigation season the mined ore is brought up in skips from below, dumped into the two pockets and thence into the ore cars. The loaded cars are then hauled to the docks and dumped into the pockets there. From here it runs by gravity into the ore vessels.

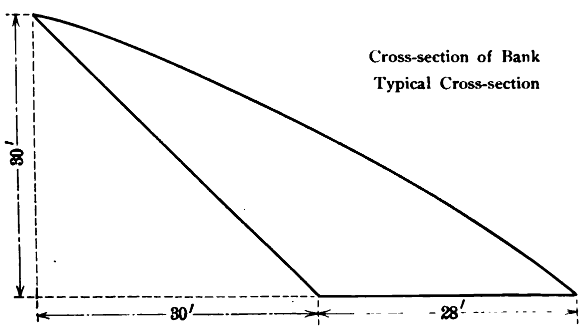
When navigation closes and it is no longer possible to ship ore, work is begun on the stock pile. The principle of construction is much like that of an immense fill on railroad work. The ore is mined and brought up in skips and dumped into the pockets as usual. From here it is dropped into cars, which are run out upon the trestle work and dumped. Usually planking is laid on the ground to receive the ore. Stock piles, of course, vary in size according to the output of the mine. This one was exceptionally large, being some 900 feet in length and almost 30 feet high. An important feature of a large stock pile is that it permits the use of a long train and materially reduces the lost time due to switching. The ore thus stored in winter is loaded into cars during the navigation season by steam shovels.

OBSERVATIONS

Type shovel	Bucyrus 70-ton
Distance of move	6′
Kind of teeth	Bucyrus, manganese lip
Height of lift	10′

OBSERVATIONS—*Continued*

Size of bucket . . . . . . 2½ yards, 4.27 tons average
Age of shovel . . . . Set up in May, 1909
Duration of job . . . . First season
Length of shift . . . . 10 hours
Number of shifts per day 1
Supplies are handled: Coal hauled by team as shown in Fig. 54. Haul about 1500′.
Water pumped from boiler house.
Repairs are made by regular crew; immediately for important ones; others at odd times.
Coal used . . . . About 2½ tons in 10 hours
Oil used . . . . Black, 0.55 gallons; cylinder, 0.89 gallon; engine, 0.66 gallon, in 10 hours.
Water used . . . . 4500 gallons in 10 hours
Boiler cleaned once in four weeks, on Sunday.
Cost of repairs . . 4 hours (reported) in 23 days at $2.18 an hour, equals 38 cents a day.
Kind of track . . . . . . 45-pound, standard gauge
American Car and Foundry Co. steel ore cars, capacity 40 tons, but carrying 47 tons each.
Train is braked by air.
Hand signals used.
Kind and size of dinkey: Fairly heavy switch engine is used.
One engine for spotting.
All repairs to cars and engine made by railroad company by whom they are owned.



TIME STUDY

The shovel did not work on the 11th, the day that time study was to have been made, so the deductions are made from the following office record.

OFFICE RECORD OF SHOVEL

Date	Cars 47 Tons	Switching Min.	Moving Shovel Min	Miscellaneous Min.	Time Worked Hours
August 9	85	103	75	75	10
August 7	78	89	84	15 (1) 79	10
August 6	80	113	89	54	10
August 5	67	99	94	115 (2) 50	10
August 4	66	121	88	44	10
August 3	53	148	69	140	10
July 20	58	188	56	83	10
July 19	69	132	60	101	10
July 17	68	140	64.	101	10
July 13	64	56	54	215	10
July 12	62	135	70	97	10
July 8	81	102	90	141	10
July 9	67	69	65	147	10
July 7	56	66	68	35 (3) 160	10
July 4	69	42	54	15 127	10
June 30	48	83	70	65	10*
June 25	40	53	52	210	10 Blast often
June 22	51	106	48	110	10
June 21	56	60	58	105 (4) 53	10
June 12	60	67	66	100	10
June 11	74	73	78	Noon(5) 20	10
July 6	70	83	73	167	10
July 3	58	91	58	120	10
Total . .	1480	2219	1583	2750	230
Average .	64.3	92½	69	120	10

(1) Small repair item, 15 minutes. No cause given.
(2) Cable on swing engine broke, causing delay of 1 hour and 55 minutes.
(3) Nipple on exhaust of crane engine broke, causing delay of 35 minutes.
(4) Putting new stud in pillow block of main engine, causing delay of 2 hours and 45 minutes.
(5) Replacing clutch on propeller shaft, delay, 1 hour.
Note—Average time moving up, 8 minutes.
*Pick bank, car shortage on this day.

DEDUCTIONS FROM ABOVE DATA

Number of days worked 23
Total tons output 69,560
Tons per day 3,024

Time Lost, Average per Day	Hours	Minutes	Seconds
Moving up	1	9	
Switching	1	32.5	
Miscellaneous delays, including repairs	2		
Total delay	4	41.5	
Actual shovel time	5	18.5	
Actual shovel time, per ton	. .	. .	6.33
Actual shovel time, 47-ton car	. .	4	57
Actual shovel time, dipper	. .	. .	27

Number of tons per dipper, 4.27. 11 dippers equal 1 car.
Counting in all delays . . . . 10 hours per day
Time per ton . . . . 11.9 seconds
Time per car . . . . 9 minutes 20 seconds
Time per dipper . . . . 50.8 seconds

TIME STUDY

Average of 23 Days	Minutes	Per Cent
Actual working	318.5	53.1
Changing trains	92.5	15.4
Moving shovel	69	11.5
Miscellaneous delays	120	20.0
Total time under observation	600	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Engineer	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
	20.00

Tons excavated per day (average 23 days), 3,024. Two tons per yard, 1512 cubic yards per day.
Cost of labor per day, $20.00.

Cost of labor per day, per cubic yard (load only) $\frac{\$20.00}{1512} =$ 1.32 cents per cubic yard.

PROCESS ANALYSIS

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cents
Charge to loading					
1. Actual loading	318	30	53.1	0.701	1.117
2. Delays					
a Moving up	69		11.5	0.152	
b Repairs	120		20.0	0.264	
c Miscellaneous					
Charge to transportation					
1. Waiting for cars	92	30	15.4	0.203	0.203
	600		100		1.320

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{37,500}{5,000} = 7.5 .$$

Fig 54. Coal Car

NEWPORT MINING COMPANY.

STEAM SHOVEL REPORT.

SHAFT.............. .. ..

GRADE.............. ....190......

NO. MEN..............

TIME	CARS		TONS	DELAYS				
	S	B		Repairing	Switching	Cars	Move Shovel	Miscellaneous
7 to 8								
8 to 9								
9 to 10								
10 to 11								
11 to 12								
12 to 1								
1 to 2								
2 to 3								
3 to 4								
4 to 5								
5 to 6								
6 to 7								
7 to 8								
8 to 9								
TOTAL								

Condition of Stockpile ....

REMARKS: ....

....

....

....

....ENGINEER.

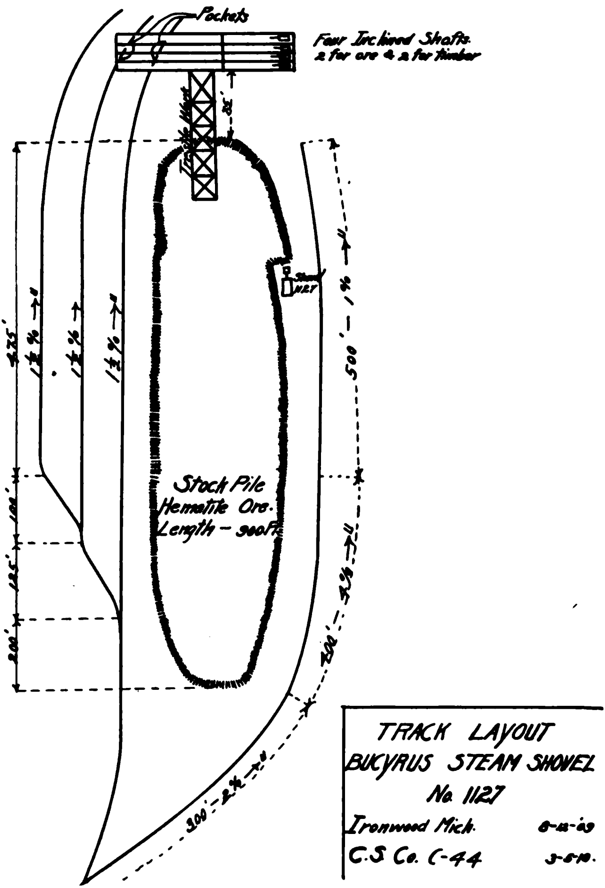

Pockets
Four Inclined Shafts.
2 for ore & 2 for timber
Trestle Work
Stock Pile
Hematite Ore.
Length – 900 Ft.
1¼% →"
1½% →"
1¼% →"
275'
100'
125'
200'
500' – 1% →"
700' – 3½% →"
300' – 2% →"
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No. 1127
Ironwood Mich.
C.S. Co. C-44

Fig. 55. View Showing Method of Forming Stock Pile

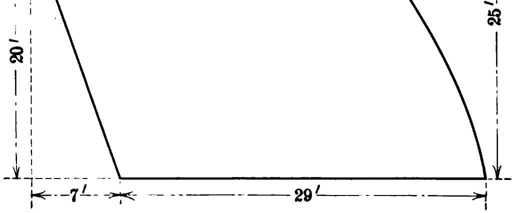
REPORT No. 25—SHOVEL No. 1142

INSPECTED AUGUST 6, 1909

STAMBAUGH, MICH.

GENERAL CONDITIONS This shovel, a 70 C, is owned by the Munro Iron Mining Company and was purchased for stock pile work.

PERFORMANCE The shovel was new in the summer of 1909 and at the time of the inspection had worked eighteen days with an output of 34,590 tons. Unfortunately this time the shovel was not working and so no timing could be done. However, the superintendent stated that it averaged half time at actual work. The best run the shovel had made in one day was 88 cars of 38 tons each.



Cross-section of Bank. Typical Cross-section

OBSERVATIONS

Type of Shovel . . . . 70-ton Bucyrus
Material . . . . Soft Hematite ore
Distance of move . . . . 6′
Kind of teeth . . . . Steel lip
Lift . . . . 9′-high
Size of ties under shovel . . . . 6″ x 8″
Size of bucket 2½-yard
Age of shovel . . . . First season
Job ran 18 days.
Shift, 10 hours.
One shift per day.
Coal is generally hauled about 100 feet by team.
Water is pumped from boiler house.
Repairs are generally made by regular crew while waiting for cars.
Coal used . . . . 2 tons running ¾ of a day
Water used . . . . About 3000 gallons
Cost of repairs . . Slight. Broken stems to oil cups gave the most trouble.
Kind of track . . . . . . Standard gauge ; about 45 pounds
Use Williamson & Pries cars Average 38 tons capacity.
Train is braked by air.
Hand signals are used
Kind and size of dinkey . . . One light switch engine used
Weather . . . . Clear, but shovel not working

TIME STUDY

Days worked 18
Total output . . . . 34,590 tons

	Minutes	Per Cent
Actual working (average 18 days) . .	300	50
Spotting cars / Waiting for cars (average 18 days) .	150	25
Moving shovel / Miscellaneous delays (average 18 days)	150	25
Total time per day (average)	600	100

Cost of Direct Labor (Loading) Per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6.00
	$17.00

Number of tons loaded per day (average of 18 days) . . 1922
Number of cubic yards loaded per day (2 tons per yard) . 961

$$\frac{\text{Cost of labor per day}}{\text{Number of cubic yds. per day}} = \frac{\$17.00}{961} = 1.77 \text{ cents per cubic yd.}$$

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loading					
1. Actual loading . .	300	00	50.0	0.885	1.3275
2. Delays					
a Moving up . . / b Repairs . . . / c Miscellaneous .	150	00	25.0	0.4425	
Charge to transportation					
1. Waiting for cars . .	150	00	25.0	0.4425	0.4425
	600	00	100.0	. . .	1.7700

ACTUAL RATIO

$$\frac{\text{Water consumed, pounds}}{\text{Coal consumed, pounds}} = \frac{25{,}000}{4{,}000} = 6.25$$

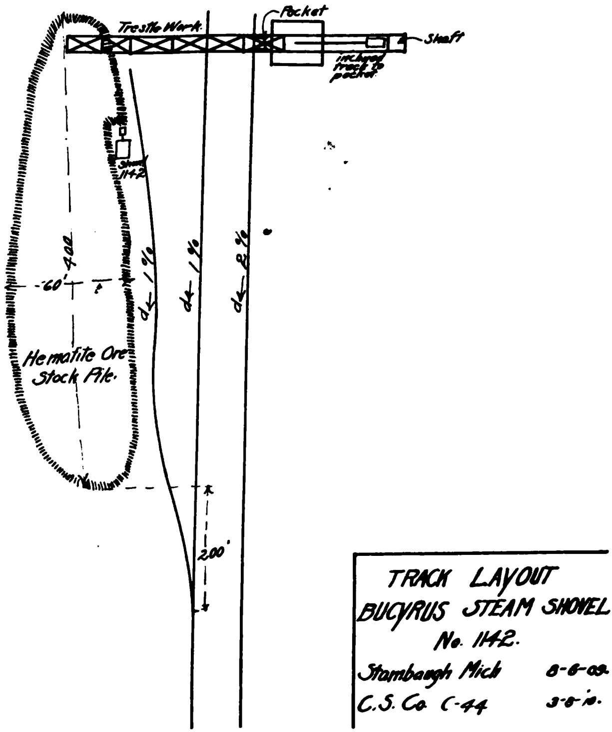

Trestle Work
Pocket
Shaft
inclined track to pocket
Shovel 1142
400'
60'
Hematite Ore Stock Pile
d ← 1%
d ← 1%
d ← 2%
200'
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No. 1142.
Stambaugh Mich 8-6-09.
C.S. Co. C-44 3-8-10.

Fig. 56 Bucyrus Shovel No 1142 at Stambaugh, Mich.

Fig. 57. View showing rocks encountered by Shovel No. 1124 in Mine Stripping at Michagamme, Mich.

REPORT No. 26 — SHOVEL No. 1124

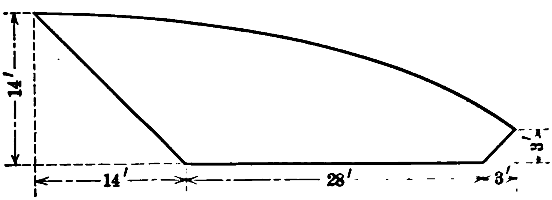
INSPECTED JULY 29 and 31, 1909

HOOSE & PERSON, CONTRACTORS

MICHIGAMME, MICH.

GENERAL CONDITIONS This shovel was installed about the middle of March and began work about the first of April. This mine said to be the first in Michigan to use the steam shovel for open pit work. The ore was covered with a 10-foot layer of earth, which had to be stripped. Pit stripping was hardpan and boulders. Standard gauge Oliver dump cars of 6½ yards capacity were used.

PERFORMANCE The contractors stated that an average of 800 yards was stripped each day of ten hours. The principal drawback to a larger output was poor train service, which seems to be the chief difficulty at most of the mines visited. The large masses of rock and boulders encountered offered no difficulties at all. Boulders up to 3 and 4 yards each were tossed aside with the greatest ease. It is much like working in an immense borrow pit. The contractor estimated that moving back 500 feet and cutting in would take the regular crew and two extra pitmen 5 hours; throwing track and putting in shape for train, fifteen men 5 hours.



Cross-section of Bank. Typical Cross-section

OBSERVATIONS

Type of shovel . . . . 70 C
Material . . . . Soft Hematite ore, in natural bed
Distance of move . . . . 6′
Kind of teeth . . . . Panama
Height of lift . . . . 11′
Size of ties under shovel, 6″ x 8″. Hand spikes in end and when moving shovel 2 pitmen carried two ties, one end of each in each hand.
Size of bucket . . . . 2½ yards
Age of shovel . . . . New April, 1909
Duration of job . . . . Began April 1st
Length of shift . . . . 10 hours
Number of shifts per day 1
How supplies are handled. Water pumped from well 100 yards away.
Repairs made by regular crew while waiting for cars, or at night.
Coal used . . . . 1½ to 2 tons per day of 10 hours
Oil used . . . . { Black, 3 quarts in 10 hours; Valve, 2½ quarts in 10 hours }
Water used . . . . 3000 gallons in 10 hours
Boiler is cleaned every two weeks at night.
Cost of repairs large. 1 set of Panama teeth per month, $100. Also 50 cents a day for small items.

Contract price:

Stripping . . . . { Hardpan, 40 cents a yard; Rock . 55 cents a yard }
Mining . . . . { Ore . 30 cents a ton; Rock . 60 cents a yard }

Contract includes putting ore in cars, stripping and dumping.
Kind of track . . . . Standard gauge, 50-pound rail
Kind and size of cars used: American Car and Foundry Co. ore car, 30 tons; American Car and Foundry Co. ore car, 20 tons; D., S. S. & A. R. R. ore car, 25 tons.
Train is braked by air.
Kind of signals used: Hand signals, brakeman on bank.
Kind and size of dinkey, D., S. S. & A. R. R. 35-ton yard engine
Length of haul . . . . 1500′ to empty cars
One engine used.

Cars and engine are owned by the railroad company, who see to all repairs.

Weather . . . . Clear and windy

TIME STUDY

	Forenoon	Afternoon	
Started work	8:31:50	12:45:30	12:38:20
Stopped work	11:38:45	4:41:05	2:04:40

Min. Sec Min. Sec. Min. Sec.

Total time worked 86 20 + 186 55 + 235 35 = 8 hours 28 minutes 50 seconds.

	Minutes	Seconds	Per Cent
Actual working	256	38	50.4
Waiting for cars	152	17	30.0
Moving shovel	38	45	7.6
Miscellaneous delays			
Chain off sheave	61	10	12.0
Total time under observation	508	50	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6.00
	$17.00

Cars loaded in two days, 119 @ 30 tons = 3570 tons = 1785 tons per day.

Cubic yards loaded per day (2 tons per cubic yard) $= \frac{1785}{2} =$ 892½.

$\frac{\text{Cost of direct labor per day}}{\text{No. of cubic yards per day}} = \frac{\$17.00}{892.5} =$ 1.90 cents per cubic yard.

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost Cents
Charge to loading					
1. Actual loading	256	38	50.4	0.958	1.330
2. Delays					
a Moving up	38	45	7.6	0.144	
b Repairs	61	10	12.0	0 228	
Charge to transportation					
Waiting for cars	152	17	30.0	0.570	0.570
	508	50	100.0		1.900

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{25{,}000}{3{,}000 \text{ to } 4{,}000} = 8.33 - 6.25$$

Time Study Deductions	Number of Obser-vations	Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	9	2	10	4	18	6	50
Time between moves, shovel working . .	10	11	40	25	40	43	20
Time between trains .	15	3	30	10	9	28	20
Time per train, loading	18	5	25	14	15	28	15
Time per dipper . .	10	..	22.8	..	26.5	..	32.6
No. of dippers per move	10	28		56.9		87	
No. of dippers per train	18	17		31.6		54	
No. of dippers per car	..	..		6.77		..	

Average tonnage per dipper 4.43
Number of trains loaded 18
Number of cars loaded 84

	Train Number	20-Ton Cars	25-Ton Cars	30-Ton Cars
Cars per train	1	5	..	..
	2	1	1	4
	3	2	1	2
	4	1	..	3
	5	3	..	..
	6	5	..	..
	7	2	..	3
	8	3	..	2
	9	..	..	5
	10	4	..	1
	11	3	..	2
	12	2	..	2
	13	4	..	..
	14	4	..	..
	15	1	3	1
	16	6	..	..
	17	1	1	2
	18	4	..	..
Total . . .	. . .	51	6	27

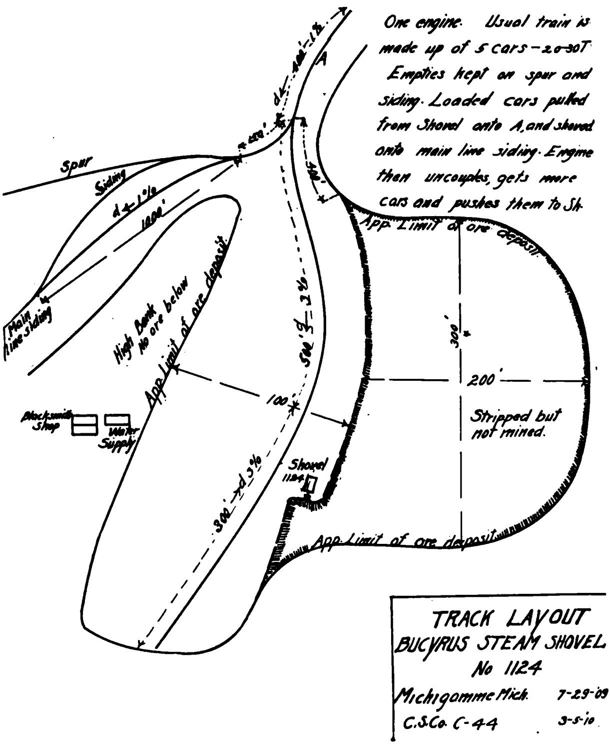

One engine. Usual train is made up of 5 cars - 20-30T Empties kept on spur and siding. Loaded cars pulled from Shovel onto A, and shoved onto main line siding. Engine then uncouples, gets more cars and pushes them to Sh.
Spur
Siding
d ← 1%
1800'
Main line siding
A
High Bank No ore below
App. Limit of ore deposit
App. Limit of ore deposit
App. Limit of ore deposit
500' d 3%
300' → d 3%
100'
300'
200'
Stripped but not mined.
Shovel 1124
Blacksmith Shop
Water Supply
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No 1124
Michigamme Mich. 7-29-09
C.S.Co. C-44 3-5-10

Fig. 58. 12-ton Boulder Encountered by Shovel No. 1124

REPORT No. 27 — SHOVEL No. 1074

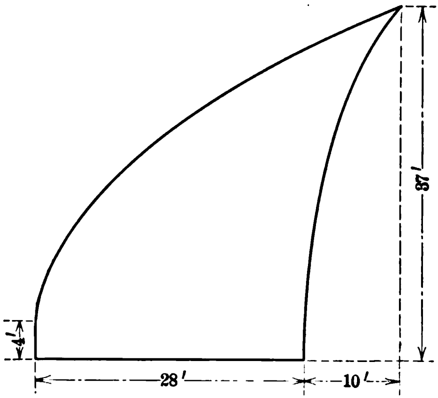
INSPECTED JULY 30, 1909

ISHPEMING, MICH.

GENERAL CONDITIONS This shovel belongs to the Pittsburg and Lake Angeline Mining Company, at Ishpeming, Mich. It was engaged in stock pile work similar to that of Shovel No. 866, page 245. The stock pile here was not frozen, and it rested on planking which greatly facilitated moving up. The height of this stock pile was very noticeable. It was at least 37 feet, and caused considerable trouble because of the overhanging of the bank when undercut by the shovel.

MOVING BACK In view of this fact the method of keeping a continuous track behind the shovel was used, so that it could move back at a moment's notice. This was done by having enough extra 6-foot sections of rail which could be left behind in place until the shovel had moved forward far enough for a regular full length rail section to be put in by the track gang. When the shovel became buried, the first thing to do was to clear the jacks, the next to move back, and the last to shovel up the fallen material and then move ahead until another slide occurred.

TRANSPORTATION Here as at most of the mines in northern Michigan, there was one engine to spot cars and draw them out to the main line siding. Each day a string of empties was brought in by a main line engine and the supply of cars for the shovel was taken from these by the spotting engine.



Cross-section of Bank. Typical Cross-section

OBSERVATIONS

Kind of teeth	Manganese lip
Height of lift	9'
Size of ties under shovel	6" x 8" and 6" x 6"
Size of bucket	2½ yards
Age of shovel	Second season
Duration of job	Began June 3, 1909
Length of shift	10 hours
Number of shifts per day	1

Coal is brought up by wagon and shoveled into bunkers. Water from city mains.

Repairs are made by regular crew while waiting for trains, or at night; average about 50 cents per day.

Coal used	2½ tons in 10 hours
Oil used	Valve, 2 quarts in 10 hours Engine, 1 pint in 10 hours Black, 1½ quarts in 10 hours
Water used	About 3500 gallons in 10 hours

Boiler is cleaned once a month.

Kind of track, weight of rail, gauge: Track, 45 pounds; standard gauge.

Kind and size of cars used: 50-ton P. S. Car Co. pressed steel cars, and L. S. and T. 40-ton wood cars.

OBSERVATIONS—*Continued*

Train is braked by air.
Hand signals are used, brakeman on car.
Kind and size of dinkey: Engine and cars belong to railroad company, who make all repairs. Engine about 35-ton.
Length of haul: About 1/8 mile before empty cars could be obtained. One spotting engine and one main line engine.

TIME STUDY

	Forenoon	Afternoon
Started work	10:03:20	12:57:57
Stopped work	12:00:00	5:03:00

Total time worked 116 minutes 40 seconds + 245 minutes 3 seconds = 361 minutes 43 seconds = 6 hours 1 minute 43 seconds.

	Minutes	Seconds	Per Cent
Actual working	121	41	33.6
Waiting for cars	222	40	61.7
Moving shovel	13	22	3.6
Miscellaneous delays	4	0	1.1
Total time under observation .	361	43	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
5 pitmen	7.50
	$18.50

Number of cars loaded on day of observation, 43 @ 45 tons (average).
Number of cubic yards loaded on day of observation (2 tons per yard) $= \frac{1935}{2} = 967$.

$$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$18.50}{967} = 1.91 \text{ cents per cubic yard}$$

Process Analysis	Time		Per Cent	Cost per Yards in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loading					
1. Actual loading . .	121	41	33.6	0.642	0.732
2. Delays					
a Moving up . . .	13	22	3.6	0.069	
b Miscellaneous . .	4		1.1	0.021	
Charge to transportation and dumping					
1. Waiting for cars . .	222	40	61.7	1.178	1.178
	361	43	100.0	. . .	1.910

Time Study Deductions	Observations	Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle . . .	8	1	05	1	40	3	45
Time between moves, working	8	10	25	15	13	21	55
Time between trains .	2	14	15	21	47	29	20
Time per train loading	5	10	40	24	53	49	13
Time per dipper . .	288		20		25		28
No. of dippers per move	8	26		36		49	
No. of dippers per train	5	30		$57\frac{3}{5}$		93	
No. of dippers per car	33			8.7			

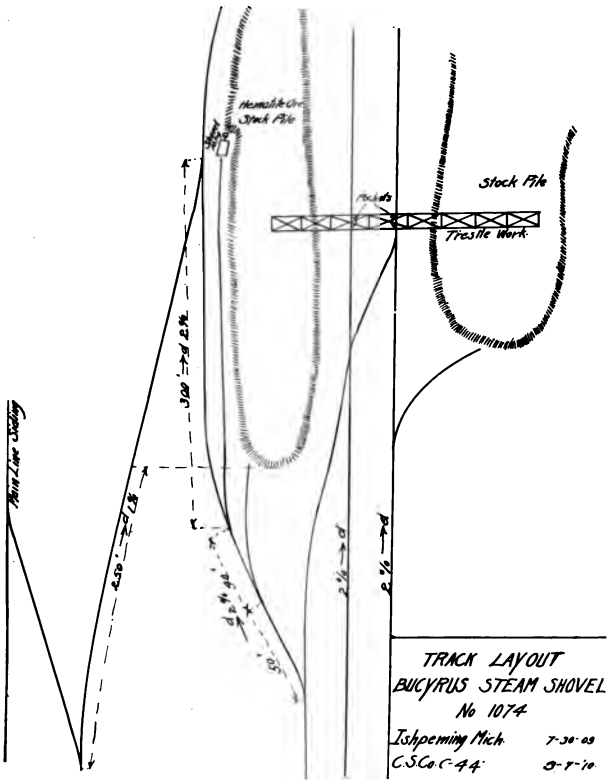
No. of trains loaded . . 5 | No. of cars 33*

*33 cars loaded during observation ; 43 loaded during day.

	Train No.	50-Ton Cars	30-Ton Cars
Cars per train	1	3	. .
	2	2	2
	3	5	7
	4	8	2
	5	4	. .
	. .	22	11

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{29{,}160}{5{,}000} = 5.83$$


Hematite Ore Stock Pile
Stock Pile
Pockets
Trestle Work
Main Line Siding
TRACK LAYOUT
BUCYRUS STEAM SHOVEL
No 1074
Ishpeming Mich. 7-30-09
C.S.Co. C-44 3-7-10

REPORT No. 28—SHOVEL No. 1083

INSPECTED SEPTEMBER 24, 1909

OLIVER IRON MINING COMPANY

SELLER'S PIT, HIBBING, MINN.

MATERIAL This shovel was working in the soft ore typical of the Mesabi Range. There was considerable taconite mixed with it and some "paint rock." These materials did not occur in the form of regular intrusions, but were scattered through the ore in lumps 6 inches in diameter and upwards. Sometimes pieces too large for one man to handle were encountered. The paint rock was in smaller chunks and so soft that it was broken by the dipper which penetrated it. When completely disintegrated it was loaded with the ore, but when encountered in pieces large enough to be picked by hand, it was thrown aside to be loaded with the taconite.

METHOD OF HANDLING Whenever pieces of paint rock or taconite were torn loose by the dipper and rolled down into the pit, one of the rockmen would pick it out and throw it into the corner of the pit next to the track. When the chunks stuck in the slope of loose material a rockman would run up the slope during the swing of the dipper and try to loosen it.

Great care was exercised in excluding foreign matter from the cars, and for this reason it was often necessary to stop the shovel completely.

The delays in getting rock out of the way generally followed a process called "clawing down." Although the ore had been shot, there often seemed to be masses that remained almost undisturbed, especially near the top of the bank. Doubtless the natural solidity of the ore is affected by the blasting, but not to such an extent that the material will crumble and fall down of itself.

In such event the dipper with bottom open is dragged across the face of the ore which drops to the bottom of the pit. Besides the clawing of the face directly in front of the shovel, this process is continued on the side as far back as the shovel can reach. There results a vertical face of ore at a distance from the shovel track equal to the extreme reach of the dipper handle.

With the tearing down of a large mass of ore by clawing, there is generally exposed or brought down a considerable amount of taconite.

TRANSPORTATION Mention has been made above of the spotting of the dump cars, which are provided for the removal of rock and foreign materials. In this case there were four 7-yard Russell Wheel and Foundry Company cars, which were spotted at the shovel after each train was loaded. When the next train came up it coupled on to these cars and they were handled as a part of the train as long as the train was loading.

The rejected material from the dump cars is thrown out on the shovel side of the car and remains scattered along the loading tracks in the shovel pit.

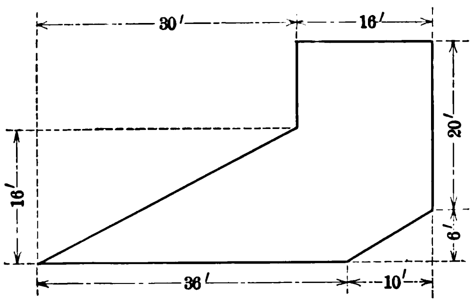
Both the shovel and loading track are standard gauge, laid with standard ties and 50 or 60-pound rails. The shovel is moved forward on 6-foot sections with the usual plate connections and bridles, but as soon as it has moved about fifty feet, a standard track, which is laid in the rear of the shovel, is extended for a rail length and is so carried along directly behind the shovel. When the shovel is ready to move back this track is connected with the shovel track and the shovel has a continuous standard track to move on. This track then becomes the loading track for the next cut, and that previously used as a loading track is torn up.

CASTING AHEAD There is another item of lost time between trains which is listed in the time study under the heading of "Casting Ahead." While loading the ore cars a small bank is formed in the pit next to the loading track. Ordinarily, as soon as a train pulls out with its load the dipper is swung over and this material is dragged back into the pit where it can be seized by the dipper when loading is resumed. In this case, however, when the loading track is not occupied by the ore cars it is by the dump cars, so little opportunity is given to load this material near the loading track. So when the empty train of ore cars comes up it pushes the dump cars out of the way and as rapidly as possible the dipper grabs this material, swings over, and dumps it directly in front of the shovel. From here it is loaded with the rest of the ore.

WORKING SEASONS The working season is limited by the shipping season on the Lakes. This generally opens on about the first of April. By the first of May the full capacity of the mine is being produced and shipped. The shipping season ends on about the first of December, although if demand for ore is good and tonnage rates are high, shipping may continue until well into December. Insurance on ships and cargoes runs out about the fifteenth of December, and but few vessel owners care to take the risk of operating after that time.

When study was made of this shovel, the mine was working apparently to full capacity. It was inspected on Saturday afternoon and a shift was to work that night and all the next day. This was very unusual, as the Oliver Company never work in their mines on Sunday and do only such shop and other work on that day as is absolutely essential. This would indicate large demand for Sellers' ore. The same was true of the Burt & Pool mines, which adjoin the Sellers.

BLASTING Shooting of the ore is done by churning holes about sixteen to twenty feet from the edge of the bank. These holes are sprung with two to four sticks of 60 per cent dynamite ⅞ by 6 inches and then loaded with black powder. About two kegs of powder are inserted in each hole. These holes are about 10 feet apart and three or four are shot at the same time. The shooting is generally done at the close of work, but the shot is sometimes fixed during working hours. There seems to be no danger from the blast, although a signal is always given for it. No attempt is made to blow the bank down, the desire being simply to give the material a slight shaking. In some cases the face of the bench blasted is hardly disturbed, while in others some of the face is thrown down, but never violently.



Typical Cross-section

OBSERVATIONS

Material	Iron ore, Bessemer grade
Type of shovel	95 B
Distance of move	6′
Kind of teeth	Rock

OBSERVATIONS—*Continued*

Lift . . . . 9′ high
Size of ties under shovel . . . . . 6″ x 6″ and 6″ x 8″ x 8′
Size of bucket . . . . 2½ yards
Age of shovel . . . . Second season
Shift . . . . 10 hours
Two shifts per day.
Coal is brought up in dump car; plank laid from car to coal bunker and coal carried across in boxes, each holding about a cubic foot. Water is taken from locomotive tender.
Repairs are made on Sundays and as needed. Completely overhauled each season in shop when needed. This shovel has never been in shop even for minor repairs.
Coal used . . . . 2¾ to 3¼ tons per shift
Oil used . . . . Valve, 1½ gallons per shift; Black, 1¼ gallons per shift; Grease, ½ pound
Water used . . . . 4000 to 6000 gallons per shift
Boiler is cleaned every second Sunday. Very clean, soft well water used.
Kind of track, etc. . . . . Standard, 60-pound rail
Kind and size of cars used: Steel ore cars, 100,000 pounds capacity; wood ore cars, 70,000 pounds.
Train is braked by air.
Hand signals are used by man on ground.
Kind and size of dinkey . . Standard locomotives, 60-ton ±
Length of haul . . . . To mouth of pit, ½ mile
Number of trains, two; two locomotives. Locomotives alternated with trains to be loaded. Locomotive would take full train out and bring in string of six empties. Would then stand on siding until other train was full and out of way.
Weather . . . . Fair, warm and sunny

TIME STUDY

	Afternoon
Started work	1:00:20
Stopped work	6:00:30

	Min.	Sec.	
Total time work	300	10	= 5 hours 10 seconds

	Minutes	Seconds	Per Cent
Actual working	173	30	57.9
Waiting for cars	71	5*	23.6
Moving shovel	9	40	3.2
Miscellaneous delays			
Taking rock from car	4	40	1.6
Breaking rock	5	15	1.8
Breaking rock	18	50	6.2
Clawing down	1	10	0.4
Clawing down	2	45	0.9
Breaking rock	2	40	0.9
Picking rock from car	9	35	3.2
Clawing down	1	0	0.3
Total time under observation	300	10	100.0

* While waiting for cars the shovel was idle 23 minutes 5 seconds out of the 71 minutes 5 seconds, but spent the remaining 48 minutes as follows:

	Minutes	Seconds
Loading rock	25	5
Clawing down	5	40
Casting ahead	17	15

Cost of Direct Labor per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6.00
8 rockmen	12.00
	$29.00

Number of cars loaded on day of observation, 23½ of 50 tons and 5 of 35 tons.

Number of cubic yards loaded on day of observation (2 tons per yard) $= \frac{1350}{2} = 675$.

Based upon the observed performance, the number of cubic yards loaded per day of 10 hours $= 675 \times \frac{600 \text{ minutes}}{300 \text{ minutes } 10 \text{ seconds}} = 1350$.

$$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$29.00}{1350} = 2.15 \text{ cents per cubic yard}$$

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to waiting for blasters	31	40	10.5	0.225	0.225
Charge to loading					
1. Actual loading . . .	173	30	57.9	1.245	1.314
2. Delays					
a Moving up . . .	9	40	3.2	0.069	
Charge to transportation					
1. Waiting for cars . . .	71	5	23.6	0.508	0.611
2. Miscellaneous . . .	14	15	4.8	0.103	
	300	10	100.0		2.150

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{33{,}000 \text{ to } 50{,}000}{5{,}500 \text{ to } 6{,}500} = 6.00 \text{ to } 7.70.$$

TIME STUDY ON SHOVEL No. 1083

This time study follows the scheme used and explained for No. 517, but a variation has been made in the column giving time "between trains."

In this case the shovel was seldom idle, even when waiting for a train. This condition is explained in the notes on No. 1083, and the itemized times are given there. While waiting the shovel was either clawing at the bank, loading stones or picking up ore along the edges of the pit and throwing it ahead where it could be more easily loaded. As this was all useful work it should hardly be classed as lost time. On the other hand it is not "loading" and so could not be counted in as useful working time. It has therefore been put in a column by itself under "Working between trains" and another column of "Between trains" time has been headed "Idle." This last is when the shovel was actually standing still.

The last column gives, as usual, "Miscellaneous delays," and in this study it contains only those items of delay that occurred while the train was at the shovel being loaded. The items which make up these delays are explained in the remarks on No. 1083.

TIME STUDY ON SHOVEL No. 1083

Began work, 1 hrs. 00 min. 20 sec.; stopped work, 6 hrs. 00 min. 30 sec. Total, 300 minutes 10 seconds

Moving Up	Loading Time of Trains	Dippers per Train	Working per Move	Dippers per Move	Time per Dipper	Between Trains: Idle	Between Trains: Working		Miscellaneous Delays While Train is Loading	
Min. Sec.	M. S.		Min. Sec.		Min.	M. S.	Min. Sec.		Min. Sec.	
..	7 30	18								
..	..	..	..	..	..	2 30	4 40	Casting ahead		
..	..	..	..	..	..	..	1 10	Loading rock		
..	46 30	81	54 00	99	0.545	..		....	4 40	Taking rock from car
..	..	..	..	..	..	0 30	9 20	Loading rock		
3 25	39 15	84	..	..	..	..		....	5 15	Breaking rock
..	..	..	..	..	..	..	2 15	Clawing down		
..	..	..	..	..	..	..	6 00	Loading rock		
..	..	..	..	..	..	..	5 35	Casting ahead		
..	..	..	..	..	..	10 35		Rep. coupler on car		
..	8 00	13	47 15	97	0.487					
2 00	29 10	69	..	..	..	..		....	18 50	Breaking rock
..	..	..	..	..	..	..		....	1 10	Clawing down
..	..	..	..	..	..	..	1 45	Clawing down		
..	..	..	..	..	..	..	3 45	Loading rock		
..	..	..	..	..	..	..	4 00	Casting ahead		
..	7 00	23	36 10	92	0.393					
4 15	25 35	67	..	..	..	..		....	2 45	Clawing down
..	..	..	..	..	..	..		....	2 40	Breaking rock
..	..	..	..	..	..	..		....	9 35	Picking rock from car
..	..	..	..	..	..	..	1 40	Clawing down		
..	..	..	..	..	..	..	4 50	Loading rock		
..	..	..	..	..	..	9 30	3 00	Casting ahead		
..	10 30	31	36 05	98	0.368	..		....	1 00	Clawing down
Tot. 9 40	173 30	386	173 30	386		23 05	48 00		45 55	
Ave. 3 13.5	38 30	85.8	43 22⅕	96½	0.448	12	10			

TIME STUDY ON SHOVEL No. 1083—*Continued*

1st train	1 steel car + 3 dippers
2d train	5 steel cars, 1 wood car
3d train	5 steel car, 1 wood car
4th train	6 steel cars
5th train	4 steel cars, 3 wood cars
6th train	2 steel cars + 4 dippers
Total cars	23½ steel, 5 wood cars
Dippers per car	14.25 steel, 10.20 wood cars

Fig. 59. View of Sellers Pit Mine in the Mesabi Range, Oliver Iron Mining Company, Hibbing, Minn.

REPORT No. 29 — SHOVEL No. 866

INSPECTED AUGUST 2-5, 1909

PRINCETON, MICH.

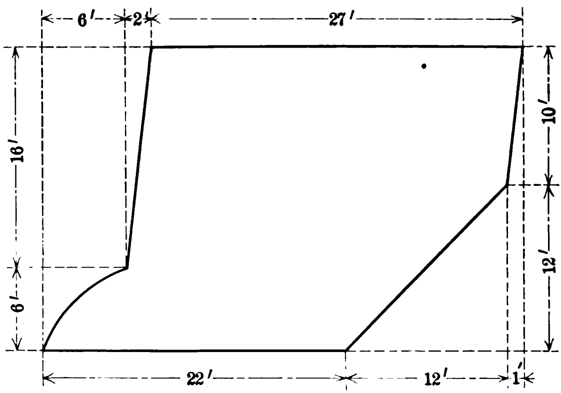
LOCATION This shovel is owned and operated by the Cleveland Cliffs Iron Co., at Princeton, Mich. On the first day of the inspection it was "cutting in."

MATERIAL AND PERFORMANCE The material being loaded was the soft Hematite Ore in stock pile. The small carts used for building stock pile are of the "end dump" type. The skips hoist the ore upward out of the shafts to a certain point above the ground, where there is a catch that restrains the top of the skip as it tends to go on up. The action is to thus automatically dump the contents of the skip into the pockets. In winter when no ore can be shipped it is dropped from the pockets into the end dump cars which run outward by gravity across a trestle to the stock pile.

In order to cut in more rapidly than is possible with the ordinary 5-foot rail sections, small 1-foot sections were used between the 5-foot rail sections to make the shovel track more flexible. The ore in this stock pile was very badly frozen in places. It occurs in this manner: A great deal of the ore is wet when it comes out of the mine, and being piled in the open air in the winter, freezes solid. It is a common occurrence on a hot summer's day to see a shovel suddenly run into ore so badly frozen and solid that the white frost is visible and the cold air felt a distance of 25 feet.

TRANSPORTATION The lack of sufficient cars was very noticeable here. On one day cars gave out after an hour's work, and there were no more until the next morning. On another day

there was a supply of cars all morning, but it gave out for the day at 1.56 P. M. One of the railroad men offered this explanation of the shortage of cars: The railroad companies own the ore pockets at the docks and their capacity is limited. Therefore when a vessel arrives for a cargo from some mine, cars are plentifully supplied to that mine until the vessel is loaded; while other mines receive only a nominal supply.



Typical Cross-section of Bank

OBSERVATIONS

Type of shovel	Bucyrus, 70-ton
Distance of move	6'
Kind of teeth	Manganese lip
Lift	11' high
Size of ties under shovel	6" x 8"
Size of bucket	3 yards
Age of shovel	Fifth season
Job began in June, this year.	
Shift	10 hours

OBSERVATIONS—*Continued*

One shift per day.

Supplies are handled: Coal, by team to point near shovel, then shoveled aboard by pitmen. Water, from a company main.

Repairs are made by regular crew either while waiting for cars or at night.

Coal used . . . . 2½ tons in 10 hours

Water used . . . . 3000 gallons

Oil used . . . . Black, 3 quarts in 10 hours; Cylinder, 3 quarts in 10 hours; Engine, 1½ quarts in 10 hours

Boiler is cleaned about once a month.

Repair cost small, but company would give no figures. Plates had to be put on the front of the bucket near rim to save the latter from wearing out. True also of Lake Angeline Mine shovel, No. 1074.

Kind of track . . . . . . Standard gauge, about 60 pounds

Cars used . . 50-ton pressed steel; 30-ton wooden L. S. & I.

Train is braked by air.

Hand signals are used. Man on shovel.

Kind and size of dinkey. Large Baldwin 4-wheel driver.

Length of haul . About ⅛ mile before engine reached empties

Cars and engines owned by railroad company, who make all repairs.

Weather . . . . Clear and bright

TIME STUDY

First Day	Forenoon	Afternoon
Started work	7:00:00	1:04:45
Stopped worked	12:02:00	6:02:45

Total time worked 302 Min. + 298 Min. = 600 minutes = 10 hours

	Minutes	Seconds	Per Cent
Actual working	170	40	28.4
Waiting for cars	311	45	52.0
Moving shovel	61	20	10.3
Pulling track	42	30	7.1
Miscellaneous delays	13	45	2.2
Total time under observation . .	600	0	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
	$20.00

Number of cars loaded on first day of observation = 39 @ 47 ton
Number of cubic yards loaded on first day of observation (2 ton per yard) $= \frac{1833}{2} = 916\frac{1}{2}$.

$$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$20.00}{916.5} = 2.19 \text{ cents per yard.}$$

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost Cents
	Min.	Sec.			
Charge to loading					
1. Actual loading	170	40	28.4	0.622	0.896
2. Delays					
a Moving up	61	20	10.3	0.226	
b Miscellaneous	13	45	2.2	0.048	
Charge to transporting and dumping					
1. Waiting for cars	311	45	52.0	1.139	1.294
2. Miscellaneous	42	30	7.1	0.155	
	600	00	100.0	...	2.190

Time Study Reductions	Number of Observations	Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time of moving up, shovel idle	7	5	30	8	46	13	40
Time between moves, shovel working	7	15	20	24	02	47	50
Time between trains	3	15	10	17	30	19	00
Time pér train loading	7	18	00	24	23	31	10
Time per dipper	335	..	23	..	30	..	37
No. of dippers per move	7	32		48		95	
No. of dippers per train	7	36		49		64	
No. of dippers per car	39	..		8¾		..	

Number of trains loaded 7
Number of cars loaded 39

	Train Number	50-ton Cars	30-ton Cars
Cars per train	1	4	1
	2	3	1
	3	4	1
	4	5	1
	5	2	3
	6	2	4
	7	5	3
	. . .	25	14

TIME STUDY

Second Day	Forenoon	Afternoon
Started work	7:00:00	12:50:00
Stopped work	11:59:30	5:48:30

	Min.	Sec.		Min.	Sec.		
Total time worked	299	30	+	298	30	=	598 minutes

= 9 hours 58 minutes.

	Minutes	Seconds	Per Cent
Actual working	170	52	28.6
Waiting for cars	306	30	51.2
Moving shovel	50	38	8.5
Miscellaneous delays			
Car off track	25	30	4.3
Repairing dipper hinge . .	8	00	1.3
Repairing connecting rod caps	36	30	6.1
Total time under observation .	598	00	100.0

Cost of direct labor per day (loading) $20.00
Number of cars loaded on second day of observation, 38 @ 47 tons = 1786 tons.
Number of cubic yards loaded on second day of observation $\frac{1786}{2} = 893.$

$$\frac{\text{Cost of direct labor per day}}{\text{Number of cubic yard per day}} = \frac{\$20.00}{893} = 2.24 \text{ cents per yard.}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost Per Yard in Cents	Total Cost
Charge to loading					
1. Actual loading . . .	170	52	28.6	0.640	0.997
2. Delays					
a Moving up . . .	50	38	8.5	0.191	
b Repairs	44	30	7.4	0.166	
Charge to transporting and dumping					
1. Waiting for cars . .	306	30	51.2	1.147	1.243
2. Miscellaneous . . .	25	30	4.3	0.096	
	598	00	100.0	. . .	2.240

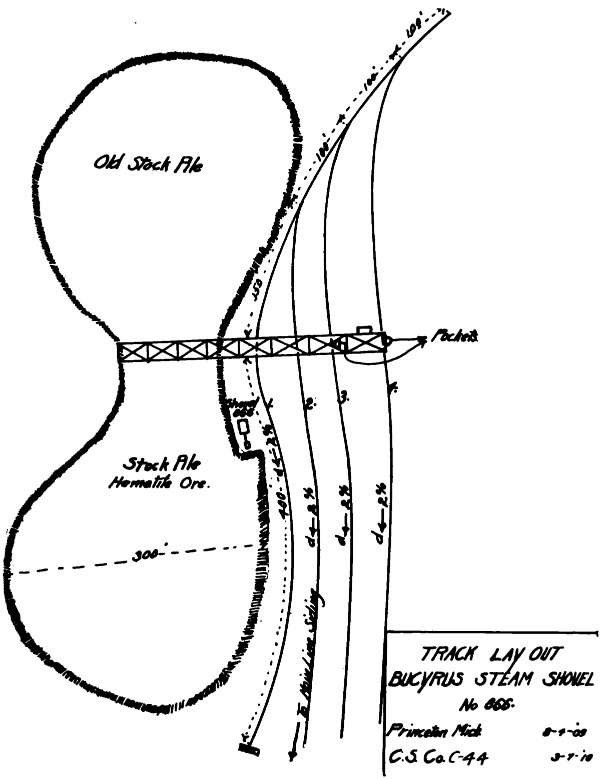
Time Study Reductions	Number of Observations	Minimum Min.	Minimum Sec.	Average Min.	Average Sec.	Maximum Min.	Maximum Sec.
Time of moving up, shovel idle . . .	7	5	55	7	14	11	25
Time between moves, shovel working . .	8	12	10	21	21	33	40
Time between trains .	4	16	25	20	48	24	15
Time per train loading	5	22	50	34	10	48	50
Time per dipper . .	344		22		29		34
No. of dippers per move	8	33		43		59	
No. of dippers per train	5	51		69		86	
No. of dippers per car	38			9			

Number of trains loaded	5
Number of cars loaded	38

	Train Number	50-Ton Cars	30-Ton Cars
Cars per train	1	3	4
	2	6	2
	3	7	0
	4	1	7
	5	1	7
		18	20

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{25{,}000}{5{,}000} = 5.0$$


Old Stock Pile
Stock Pile
Hematite Ore.
300'
150'
100'
Pockets
Shovel 666
1.
2.
3.
4.
400' d←2%
d←2%
d←2%
d←2%
To Main Line Siding
TRACK LAY OUT
BUCYRUS STEAM SHOVEL
No 666.
Princeton Mich
C.S. Co. C-44

CHISHOLM, MINN.

TAKING DOWN BOOM AND DIPPER

Shovel No. 700 was being dismantled preparatory to taking boom and dipper into the shop. The process is as follows: An empty flat car is placed on the track directly ahead of the shovel. The dipper is then thrust out as far as possible by the crane engine and allowed to rest on the far end of the flat car and on the left hand side. The hoisting chain is then slackened and the bight pulled down between the two sides of the dipper handle. A stout rod is then thrust in between this bight and the underside of the dipper handle near its upper end. After disengaging dipper handle from the rack pinions, it is slowly lowered to the flat car by paying out the hoisting chain. The hoisting chain is then released from the padlock and wound up on the drum. The end of the hoisting chain is then pulled out and passed over a pulley suspended from the A frame; thence up the boom and around a sheave at its top and thence back to the top of the A frame to one leg of which it is securely fastened. The boom is then raised slightly by the hoisting engines until the strain is removed from the tie rods which connect the upper end of the boom and the top of the A frame. These tie rods are now uncoupled from the top of the A frame and gradually eased down onto the car. The method used for thus lowering the tie rods is as follows: A stick of round timber some 4 inches in diameter and 4 feet long, to which a pulley is lashed, is jammed into the head of the A frame. Through this block a rope passes from below and is secured to the upper end of the tie rods, one at a time. A workman holds the lower end of the rope, and so the tie rods are let down gently.

The boom itself is now supported only by the hoisting chain and this is now slacked away until boom rests on the right hand side of the flat car. The hoisting

chain is then disengaged and wound up on the drum. The shovel then backs up a little, thereby removing the lower end of the boom from its socket. A timber is then placed between the front of the shovel proper and the end of the boom and the shovel moved forward until the boom is pushed over the flat car far enough to be clear of the end. The only thing remaining to be done is to take down the block suspended from the top of the A frame and place it on the car with the boom and dipper.

The photograph shows a similar 90-ton shovel after it has been dismantled and its boom and dipper loaded on flat car for transportation.

Fig. 60. 90-ton Shovel Dismantled for Shipment

CHAPTER IX

STEAM SHOVEL WORK IN ROCK

It will be noted, from the study of the data in this volume, that as the material becomes more irregular in quality the unit cost rises. This effect is more noticeable in the case of variations in the size of the individual pieces handled than in the density of the material itself. For example, there is more difference in the economic results of handling earth mixed with large boulders than there is in handling good earth, which is comparatively light, and well broken iron ore, which is comparatively heavy.

Another cause of inefficient work is the lack of coordination between the different processes. For example, if rock is badly blasted, or if the steam shovel has to wait for blasts, the necessary cost of loading the rock is considerably greater than it would otherwise be, owing to delay caused by the inefficiency of the previous process. Thus, on some classes of work, it is very difficult to tell how much of the delay or extra expenses are due to the loading process and how much are due to the breaking or loosening process.

The variations in the quality and sizes of the materials are a further cause of delay in the transportation and dumping processes. A large piece of rock that gets wedged in the side of a car and delays a train in getting back to the shovel is a real cause of expense, and yet it is difficult to classify that expense between the three processes. It is perhaps the fault of the breaking process that it should have been so large. It has already delayed the steam shovel in getting it on the car, and with some types of equipment and some classes of men the delay to the dumping on account of it is much less than with more experienced men and with other classes of cars.

TIME STUDY ON SHOVEL No. 1083

Began work, 1 hr. 00 min. 20 sec.; stopped work, 6 hrs. 00 min. 30 sec. Total, 300 minutes 10 seconds

Moving Up	Loading Time of Trains	Dippers per Train	Working per Move	Dippers per Move	Time per Dipper	Between Trains: Idle	Between Trains: Working		Miscellaneous Delays While Train is Loading	
Min. Sec.	M. S.		Min. Sec.		Min.	M. S.	Min. Sec.		Min. Sec.	
..	7 30	18								
..	..	..	..	..	..	2 30	4 40	Casting ahead		
..	..	..	..	..	..	..	1 10	Loading rock		
..	46 30	81	54 00	99	0.545	..		....	4 40	Taking rock from car
..	..	..	..	..	..	0 30	9 20	Loading rock		
3 25	39 15	84	..	..	..	..		....	5 15	Breaking rock
..	..	..	..	..	..	..	2 15	Clawing down		
..	..	..	..	..	..	..	6 00	Loading rock		
..	..	..	..	..	..	..	5 35	Casting ahead		
..	..	..	..	..	..	10 35		Rep. coupler on car		
..	8 00	13	47 15	97	0.487					
2 00	29 10	69	..	..	..	..		....	18 50	Breaking rock
..	..	..	..	..	..	..		....	1 10	Clawing down
..	..	..	..	..	..	..	1 45	Clawing down		
..	..	..	..	..	..	..	3 45	Loading rock		
..	..	..	..	..	..	..	4 00	Casting ahead		
..	7 00	23	36 10	92	0.393					
4 15	25 35	67	..	..	..	..		....	2 45	Clawing down
..	..	..	..	..	..	..		....	2 40	Breaking rock
..	..	..	..	..	..	..		....	9 35	Picking rock from car
..	..	..	..	..	..	..	1 40	Clawing down		
..	..	..	..	..	..	..	4 50	Loading rock		
..	..	..	..	..	..	9 30	3 00	Casting ahead		
..	10 30	31	36 05	98	0.368	..		....	1 00	Clawing down
Tot. 9 40	173 30	386	173 30	386		23 05	48 00		45 55	
Ave. 3 13.5	38 30	85.8	43 22½	96½	0.448	12	10			

car body is square at the ends and unprotected with wooden buffers, as on some of the other types. The boom and dipper handle are made of wood, reinforced with iron plates on the faces. There is a device for dropping the ashes by pulling a lever and a similar device for turning the grate. Water and coal are supplied in the usual way, except that the hose is attached to a pipe running up the side of the shovel and entering the tank at the top. By having all three machines of the same type the contractor is able to keep a larger supply of extra parts on hand. The wooden boom and dipper handle give more limberness, and consequently they stand rougher usage.

Another advantage which these machines have, is that the jacks can be swung toward the shovel, so that in passing boulders or through narrow places the jack braces only have to be loosened and the jacks swung to one side. The advantage of this was shown twice during our inspection, once while moving forward, when the jack hit a piece of ledge, to have passed which, without swinging the jack would have taken considerable time; and once while moving back beside a tumbled down stone wall.

The contractors report a very light repair bill so far, the only items being a new pinion for the dipper engine and new teeth for the dipper.

ARRANGEMENT OF PLANT The track arrangement for this job is very simple. The shovels are separated from each other by a swamp about 1000 feet long, and the ends of excavation shown on the sketch are not identical. In both cases a single track and only two trains are used (three new dinkeys, however, arrived at the freight yard the day this inspection closed), with a turnout near the shovel. The run for No. 1108 has only a curve, but for No. 1137 the trains must be switched back along

the hillside. There are no grades against the loads and the dinkeys have no trouble in returning. The dinkey tracks at No. 1108 were at the same elevation as the shovel tracks, but at No. 1137 here was a considerable lift at the end of the day on July 3, and on July 23 the shovel was loading as high as it could reach.

Shovel No. 1108 began on the afternoon of July 1, and on the afternoon of July 21 had finished the run of 1025 feet, with an average depth of face of about 15 to 20 feet, the dinkey tracks being only a couple of feet above the shovel tracks at the maximum. On the afternoon of July 21 the shovel was started on its backward journey, but as we did not arrive at this shovel until 4.06 p. m. on the 23d, the records for this moving are incomplete, but there is enough shown to give an idea of the progress made. The method employed here was similar to that at Shovel No. 893 (see report No. 6) and consisted in laying standard length rails for a considerable distance preparatory to moving. When we arrived the rails had all been laid and had been run into the dinkey tracks, which had been widened to a standard gauge for a distance of about 500 feet. This was done by simply taking the outside spikes out of one rail and shifting it over, leaving in the inside spikes to be used when the track should be shifted back again to narrow gauge. Fig. 62 shows the shovel as it has completed its journey as the men are in the act of unbolting a section of track to swing over to the area which the other laborers are leveling.

TIME STUDY From the tables, comparisons as to the efficiencies of the two shovels will suggest themselves, but attention is called to the time necessary to fill the dipper and load the cars. The digging for No. 1137 was very hard at times, and much time was spent in trying to loosen rock that was finally

"mud-capped." On the other hand, during the morning on which No. 1108 was observed, the digging was easy, consisting of gravel with well broken sod that fell down of its own accord. At about noon, however, this changed to a hard, unbroken rock, and continued so until about 4.30. The difference between these materials is shown in a very plain manner by the average submitted in the tables.

OBSERVATIONS

Weight	70 tons
Gauge	Standard
Capacity of dipper	2½ cu. yds.
Kind of teeth	Manganese steel
Number of pitmen	6
Height blocked up	0
Weather	Clear

TRANSPORTATION

Capacity of cars, water measure	4.38 cubic yards
Capacity of cars, place measure	3.6 cubic yards
Number of cars in train	7
Height of cars above their track	6′
Length of haul (approximate)	4800′
Length of runaround	9600′
Weight of dinkeys	18 tons
Style of car	Side dump on both sides
Height of top of cars above shovel track	6′
Gauge of dinkey tracks	Narrow
Number of trains	2

Average time for round trip, 18.5 minutes; maximum, 39 minutes; minimum, 13.5 minutes; 26 observations.

Maximum grade . . . . About 2 per cent against empties

Full trains on grades.

Rate of transportation: Maximum, 711′; average, 520′; minimum, 250′.

Swings per minute	2.9
Number of cars loaded	336½
Cubic yards excavated	1200
Number of times moved forward	14
Average distance moved each time	6′ 1″
Total distance moved forward during day	85′

TRANSPORTATION—*Continued*

Time in minutes to load 1 cubic foot with dipper 012
Time shovel is interrupted while spotting one car . .009 minute
Minutes per working day, less time for accidental delays . 601½
Shovel expenses in cents, not including superintendent and overhead or preparatory charges, 3349.
Coal used . . . . 2.65 tons
Area of section . . . . 880 square feet
Height of face . . . . 20′
Average time to move forward once . . . . 9.429 minutes
Average time to move forward 1 foot . . . . 1.553 minutes
Average time to load one car . . . . 1.154 minutes
Pounds of coal per cubic yard excavated 4½
Total cost to excavate, transport and spread 1 cubic yard, 9.69 cents.
Number of cars for one shovel move 24
Maximum distance moved forward in one move . . . 7′ 2″
Average time for one swing: a. m., 19.5 seconds; p. m., 20.6 seconds.
Average time between beginning of one shovel move and beginning of next, 44.6 minutes.

TIME STUDY

	Forenoon	Afternoon
Started work	6:59	12:28
Stopped work	11:59	5:29½

Total time worked 300 + 301½ minutes = 10 hours 1 minute 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	388	18	64.6
Spotting cars	3	12	0.5
Changing trains	74	30	12.4
Moving shovel	132	00	21.9
Idle			
Boulder in tooth	0	30	0.1
Miscellaneous delays			
Tearing down bank	3	00	0.5
Total time under observation .	601	30	100.0

Direct Labor Distribution Per Day	Standard Basis					
	Breaking	Loading	Transporting	Dumping	Incidental	Total
Runner	...	$5.00	...	...	...	...
Craneman	...	3.60	...	...	...	...
Fireman	...	2.40	...	...	...	...
6 pitmen	...	9.00	...	...	...	...
1 coalman	...	1.50	...	...	...	...
2 waterboys	...	...	...	...	2.00	...
3 drillers	7.50	...	...	...	...	...
3 drillers' helpers	4.25	...	...	...	...	...
2 laborers stripping rock	3.00	...	...	...	...	...
4 laborers loading holes	6.00	...	...	...	...	...
1 boiler engineer	2.00	...	...	...	...	...
1 powderman	2.00	...	...	...	...	...
2 blacksmiths	...	...	...	...	6.00	...
2 blacksmiths' helpers	...	...	...	...	3.00	...
2 brakemen	...	...	3.00	...		
1 pumpman	...	...	...	...	1.50	...
2 locomotive engineers	...	...	5.20	...	...	...
5 dumpmen	...	...	...	7.50	...	...
Half sec. foreman	...	...	...	...	2.00	...
Superintendent	...	...	...	...	6.00	...
Half watchman	...	...	...	...	0.75	...
Total cost of labor per day	$24.75	$21.50	$8.20	$7.50	$21.25	$83.20
Cost per day per cubic yard, cents	2.06	1.79	0.68	0.63	1.77	6.93
Per cent	29.7	25.8	9.8	9.1	25.6	100.0

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to waiting for blasters	3	..	0.5	0.009	0.009
Charge to loading					
1. Actual loading . .	388	18	64.6	1.156	1.550
2. Delays					
a Moving up . . .	132	00	21.9	0.392	
b Miscellaneous . .	. .	30	0.1	0.002	
Charge to transporting and dumping					
1. Waiting for cars	77	42	12.9	0.231	0.231
	601	30	100.0	. . .	1.790

ANALYSIS OF COMPLETE DIPPER SWING

Forenoon		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging . .	Time in seconds	4	9.18	21½	25	28
Swinging loaded	Time in seconds	3	5.76	9½	23	..
Swinging and falling empty	Time in seconds	4	8.20	22½	23	..
Time to fill and load one dipperful		11	23.14	53½	..	..

Percentage of complete dipperfuls to attempts $= \frac{25}{28} = 89.3.$

Afternoon		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging . . .	Time in seconds	4½	12.5	44	23	31
Swinging loaded	Time in seconds	3	7.3	37½	22	..
Swing and falling empty .	Time in seconds	5½	8.7	17	22	..
Time to fill and load one dipperful		13	28.5	98½	..	..

Percentage of complete dipperfuls to attempts $= \frac{23}{31} = 74.2$

Time for a complete swing (seconds)

	Minimum	Average	Maximum	Number of Observations
Forenoon . . .	12	19.5	31.5	36
Afternoon . . .	14	20.6	26.0	37

Swings per minute

	Maximum	Average	Minimum	Number of Observations
Forenoon . . .	5.0	3.1	1.9	36
Afternoon . . .	4.3	2.9	2.3	37

Cost to Move Back	Standard Basis
Runner . . . . . @ 1.73 day @ $5.00	$8.65
Craneman . . . @ 1.73 day @ 3.60	6.23
Fireman . . . . @ 1.73 day @ 2.40	4.15
27 laborers . . . @ 1.73 day @ 1.50/day	70.07
1 foreman . . . @ 1.73 day @ 4.00	6.92
1 foreman . . . @ 1.73 day @ 3.50	6.06
	$102.08
Coal (1 ton)	4.00
Oil and waste	1.00
	$107.08

Total distance moved . . . . 1624′
Total time consumed . . . . 1.73 days
Number of men employed 32
Cost per foot moved . . . . 6.6 cents
Cost per foot, per man . . . . 0.21 cent

ACTUAL RATIOS $\frac{\text{Superintendence}}{\text{Direct labor}} = 0.06$

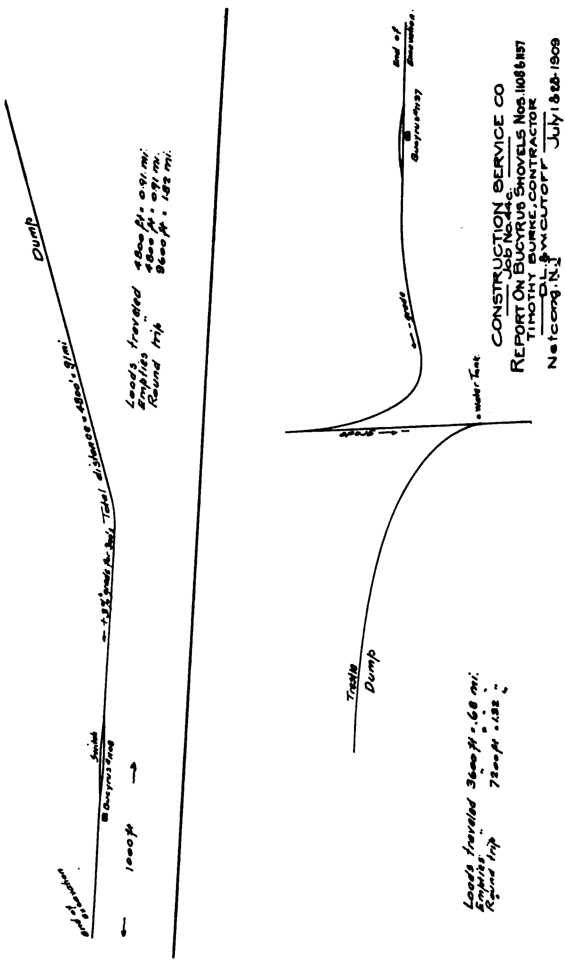

CONSTRUCTION SERVICE CO
Job No. 44c.
REPORT ON BUCYRUS SHOVELS NOS. 11086 1157
TIMOTHY BURKE, CONTRACTOR
D.L.&W. CUTOFF
Netcong, N.J.
Dump
Loads traveled 4800 ft = 0.91 mi.
Empties " 4800 ft = 0.91 mi.
Round trip 9600 ft = 1.82 mi.
1000 ft
Water Tank
Trestle
Dump
Loads traveled 3600 ft = .68 mi.

Fig. 61

Fig. 62. Shovel on the D., L. & W. R. R. Cut-off, near Hopatcong, N. J. Track being prepared for Moving Machine

REPORT No. 31 — SHOVEL No. 1138

INSPECTED OCTOBER 2 AND 8, 1909
BROWNELL IMPROVEMENT COMPANY
THORNTON, ILL.

MATERIAL With the track layout shown in the sketch, shovels No. 1073 (p. 278) and No. 1138 are turning out from 2600 to 3000 cubic yards of crushed stone a day, the material being a hard crystalline limestone, which, if October 2, 3, 4 and 5 are any criterion, is not too well blasted. It is the same sort of limestone as found on the Jas. J. Hart contract on the D., L. & W. cut-off, where it was said that powder cost 15 cents a yard. On this work powder costs from 2½ cents to 13 cents a yard. On the first day of observation (shovel No. 1073) the rock was well broken up in the morning, but during the afternoon some was encountered which came out in large slabs that had to be mud-capped, 150 pounds of dynamite being used for this purpose. On October 3d (shovel No. 1138) the digging was very easy, the rock being broken into small pieces, not over a foot in diameter. It was necessary to blast the bank only three times on this day as against eight times the previous day at No. 1073. It was on this day that No. 1138 made the best run of the four days observed, working 50 per cent. of the time and loading 300 cars. On October 4th (shovel No. 1073) the rock was fairly well broken, but parts that had not felt the effect of the blast were frequently met. On the last day of the observation (October 5th, shovel No. 1138) the digging was very hard. The rock had not been blasted properly, so that while the rock was broken it was not loosened sufficiently to make easy digging, and as insufficient powder had been used, the rock was broken at the top, but there was a ledge about two-thirds the way down the face that had not been affected, and

which had to be drilled and blasted frequently. The day this shovel was observed was the day after the track was changed. The shovel had to follow the track and had to draw away from the bank to do so, as there was a slight curve at this point. When the track was thrown it was brought very near the shovel, a little too near in fact, for when the boom was swung around into its usual position preparatory to dumping the dipper, it was found that the contents of the dipper would land on the far side of the car rather than in it. By spotting the cars a little further ahead and not swinging the boom so far around, this difficulty was overcome. However, a new dilemma presented itself, for now, on account of the boom being in the line of sight, the runner could not see to properly spot the dipper. So until the shovel had cut in again far enough to dump with the boom swung out as usual, the time per swing was somewhat increased.

DRILLING AND BLASTING The rock dips toward the shovels at about 30 degrees from the horizontal. Sixty per cent forcite in pieces 2″ x 6″ and 3″ x 8″ is used. There were four drills in front of No. 1138 and three behind, the latter drilling the holes. In front of No. 1073 there were four drills but none behind. During one week of seven days, selected at random, there were drilled 2258 feet of all large and small holes by 11 drills, or about 29 feet per drill day. The drillers work in pairs and are paid by the foot, receiving 8 cents a foot, large holes; 6 cents per first 30 feet of small holes and 7 cents a foot for all over 30 feet. A crew consists of two drills, two drillers and one helper, the latter receiving 17½ cents an hour. The large holes finish at 3½ inches. The holes are not sprung, as the material is so brittle it breaks off and fills the holes. Both top and toe holes are drilled. Ingersoll-Rand drills are used and are run by compressed air.

Dynamite costs 12½ cents a pound. At each shovel one small one-man drill was kept in addition for making holes for light blasts.

SHOVELS These shovels are the largest and strongest The Bucyrus Company makes. They weigh 95 tons and have steel-plated booms and dipper handles, the boom being swung by chain instead of cable. There are two water tanks, one on each side of the boiler, and three propelling chains instead of only two. A crew consists of engineer, craneman, fireman and four or five pitmen. There were four on No. 1073 and five on No. 1138. The engineer, craneman and fireman receive time and a half for overtime and the two former are allowed one day a week off under pay. There is an extra crew who work nights making repairs and who substitute when the regular men are away.

SUPPLIES Water is supplied to the shovel from a tank on top of the quarry. Coal is brought in on the dinkeys and put right in the bunker on the shovel, which holds about five tons. Coal costs $1.70 a ton. The boilers are washed out once a week, and this, together with the general repairs, costs about $32 a week.

TRANSPORTATION The hauling is done by four 35-ton dinkeys drawing ten car trains. There are five of these dinkeys, but one is taken in every day and washed and overhauled. Four of them are new engines. Besides these there are two others of about 50 tons, which are used for switching the large freight cars. The dinkey cars are five cubic yards capacity, weigh four tons empty and cost $150 to build. They are very substantial, being lined with sheet iron. The door is tripped automatically when the cars are

dumped. These cars ride very well and do not get off the track under ordinary conditions. No brakes are provided. A coal tender is attached to each engine.

COST KEEPING A registering clock is used to keep the time of arrival and departure of the men. From these cards the payroll is made up, and to save time the extensions are made weekly on the cards themselves. The timekeeper goes over the job during the day to check up the men. The payroll is made up on a large sheet about 10 inches by 14 inches. All purchases are made by the main office, the requisition being made in duplicate at the job. One copy is sent to the main office where it is reviewed by the manager, and if O. K., is copied in triplicate, one being kept at the main office, one sent to the dealer, and one sent to the job. The one sent to the job is in the nature of a receipt and is returned when the goods are delivered. At the job the payroll, car records or such other matter as it is desired to keep a record of, is written out with a copying pencil and copied in a copy book.

OBSERVATIONS—GENERAL

Weight	95 tons
Gauge	Standard
Capacity of dipper	2½ cubic yards
Kind of teeth	Manganese steel bases and points
Height of lift	8½', October 5; 7½', October 3
Height blocked up	0'
Number of pitmen	5
Length of boom	30' 7"
Length of dipper handle	18' 6"
Height of boom above pivot	22' 9"
Height of boom above shovel tracks	28'
Horizontal reach of boom	22'

OBSERVATIONS—GENERAL—*Continued*

Farthest dipper can reach to dump . . . . 27′
Highest dipper can reach to dump . . . . 17½′
Lowest dipper can reach to dig below shovel tracks . . . 4′
Diameter of swing circle . . . . 7′
Height of dinkey tracks above shovel tracks, October 3, 1′; October 5, 2½′.
Distance inside dinkey track to inside shovel track, October 5 A. M., 10′; noon, 15′; P. M., 18′ 10′; October 3, 19′ 10″.
Weather clear.
Depth of dipper (water measure) . . . . 46″
Depth of dipper, including lip . . . . 55″
Depth of dipper, including teeth . . . . 74″

OBSERVATIONS—FIRST DAY

Number of cars loaded 300
Cubic yards excavated 1200
Capacity of cars, water measure . . . . . . 5 cubic yards
Total distance moved forward during day . . . . . . 54′ 6″
Number of times moved forward during day 12
Maximum distance moved forward in one move . . . . 6′
Average time between beginning of one shovel move and beginning of next, 48.
Maximum time between beginning of one shovel move and beginning of next, 75¼.
Minimum time between beginning of one shovel move and beginning of next, 30.
Average number of cars to one shovel move 24
Maximum number of cars to one shovel move 30
Minimum number of cars to one shovel move 17
Time between moves when maximum was loaded, 51½, 64, 50 and 44¾ minutes.
Time between moves when minimum was loaded . 30 minutes
Average time to load one train . . . . 9¼ minutes
Number of cars in train 10
Area of section . . . . 400 square feet
Height of face . . . . 23′
Number of times blasted bank 3
Average time to make one blast . . . . 13 hours 2 minutes
Coal used, about 3 to 4 tons. Could not be ascertained accurately.
Water used, could not be ascertained; stream running constantly.

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	7:04:30	12:29:00
Stopped work	12:09:00	5:02:30

	Min.	Sec.		Min.	Sec.		Min.
Total time worked	304	30	+	273	30	=	578 = 9 hours 38 minutes.

	Minutes	Seconds	Per Cent
Actual working	289	00	50.0
Spotting cars	2	30	0.4
Waiting for cars*	(137)	(45)	(23.8)
Idle	50	45	8.8
Leveling in front	38	00	6.6
Drilling	16	30	2.8
Blasting	14	45	2.5
Preparing to move	17	45	3.1
Moving shovel	94	00	16.3
Idle	(26)	(15)	(4.6)
Blasting (cars on hand) . . .	24	45	4.3
Waiting for trains to pull out .	1	30	0.3
Miscellaneous delays Pulling in and breaking bank	28	30	4.9
Total time under observation .	578	00	100.0

*The whole of miscellaneous, and 36 minutes spent in moving up, was also accomplished while waiting for cars.

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
5 pitmen	7.50
	$18.50

Cubic yards loaded on first day of observation 1200

Based on observed performance, the cubic yards loaded per day of 10 hours $= 1200 \times \frac{600}{578} = 1245$ cubic yards.

$$\frac{\text{Cost per day of labor}}{\text{Number of cubic yards per day}} \quad \frac{\$18.50}{1245} = 1.49 \text{ cents per cubic yard}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to waiting for blasters	53	15	9.2	0.137	0.137
Charge to loading					
1. Actual loading . . .	289	00	50.0	0.745	0.988
2. Delays					
a Moving up	94	00	16.3	0.243	
Charge to transportation and dumping					
1. Waiting for trains . .	140	15	24.2	0.361	0.365
2. Miscellaneous . . .	1	30	0.3	0.004	
	578	00	100.0		1.490

Dipper Performance		Minimum	Average	Maximum	No. of Observations
Digging	Time in Seconds	2.0	5.3	14.5	76
Swinging loaded . . .	Time in Seconds	3.0	5.75	8.5	52
Swinging loaded . . .	Time in Seconds	3.0	5.75	7.5	51
Falling empty	Time in Seconds	2.5	4.5	12.5	69
Time to fill and load one dipperful	Time in Seconds	10.5	21.3	43.0	..

Time for a complete swing

	Minimum	Average	Maximum	No. Obs.	No. Attempts
Seconds . .	14	23.3	43.75	46	61

Number of observations less than 20″ = 19
Number of observations greater than 20″ = 25
Number of observations at 20″ = 2
46

OBSERVATIONS. SECOND DAY

Number of cars loaded 210
Cubic yards excavated 840
Capacity of cars, water measure . . . . . . 5 cubic yards
Total distance moved forward during day . . . . . 58′ 6″
Number of times moved forward during day 9
Maximum distance moved forward in one move . . . . . 7′
Minimum time between beginning of one shovel move to beginning of next . . . . 32 minutes
Average time between beginning of one shovel move to beginning of next . . . . 87 minutes

OBSERVATIONS. SECOND DAY—*Continued*

Maximum time between beginning of one shovel move to beginning of next	180 minutes
Minimum number of cars to one shovel move	12
Average number of cars to one shovel move	25.4
Maximum number of cars to one shovel move	43
Time between moves when minimum was loaded	35 minutes
Time between moves when maximum was loaded	145 minutes
Average time to load one train	11¾ minutes
Number of cars in train	10
Area of section	Very irregular but about 500 square feet
Height of face	23′
Number of times blasted bank	8
Average time to make one blast	9½ minutes

Coal used, about 3 to 4 tons, could not be ascertained accurately.

Water used, could not be ascertained; kept steam running constantly.

TIME STUDY. SECOND DAY

	Forenoon	Afternoon
Started work	7:16:00	12:59:30
Stopped work	12:34:00	7:13:00

	Min.	Min	Sec.		
Total time worked	318 +	373	30	=	691 minutes

30 seconds = 11 hours 31 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	243	30	35.2
Spotting cars	16	45	2.4
Waiting for cars	(59	00)	. .
Waiting for trains to be spotted	12	30	1.8
Idle	5	15	0.8
Tightening jacks	2	15	0.3
Clearing track	5	30	0.8
Blasting	33	30	4.8
Moving shovel	146	15	21.2
Idle	(193	30)	. .
Blasting (cars on hand)	41	30	6.0
Putting car on and clearing track	22	00	3.2
Clearing track	1	00	0.1
Drilling	124	45	18.1
Waiting for trains to pull out	4	15	0.6
Miscellaneous delays	(32	30)	. .
Pulling in bank to clear track	21	45	3.1
Breaking bank	10	45	1.6
Total time under observation	691	30	100.0

Cubic yards loaded on second day of observation . . . 840
Based on observed performance, the cubic yards loaded per day of 10 hours $= \frac{840 \times 600}{691.5} = 730$.

$\frac{\text{Cost per day of labor}}{\text{Number of cubic yards per day}} = \frac{\$18.50}{730} = 2.53$ cents per cubic yard.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to waiting for blasters	198	45	28.8	0.728	0.728
Charge to loading					
1 Actual loading . . .	243	30	35.2	0.890	1.426
2 Delays					
a Moving up . . .	146	15	21.2	0.536	
Charge to transporting and dumping					
1 Waiting for cars .	75	45	10.9	0.276	0.376
2 Miscellaneous delays	27	15	3.9	0.100	
	691	30	100.0	. . .	2.530

Dipper Performance		Minimum	Average	Maximum	No of Observations
Digging . . .	Time in seconds	3.5	7.5	19.0	89
Swinging loaded	Time in seconds	3.0	3.8	11.5	61
Swinging empty	Time in seconds	3.0	4.2	7.0	57
Falling empty .	Time in seconds	2.5	4.5	9.5	69
Time to fill and load one dipperful		12.0	20.0	47.0	..

Time for a complete swing

	Minimum	Average	Maximum	No. of Observations	No. of Attempts
Seconds	13.5	21.6	54	54	60

Number of observations less than 20″ = 28
Number of observations greater than 20″ = 23
Number of observations at 20″ = 3

SOME DELAYS TO THE LOADING OF TRAINS CAUSED BY THE SHOVEL, AND THE TIME CONSUMED

Delay in loading; no apparent reason . . . . . 7 minutes
Moving forward . . . . 22 minutes
Blasting . . . . 25 minutes

Some time on the various operations in moving forward:

Front clamps . . . . 22″
Moving . . . . 18″ to 32″, 18″ to 15″
Rear clamps, front trucks . . . . 42″
Rear clamps, rear trucks . . . . 45″
Carrying and placing ties . . . . 60″
Carrying and placing rails . . . . 30″
Bumper tie . . . . 6″ to 10″
Screwing jacks, jack blocks and swinging . . . 3′ 4″ to 3′ 6″
Leveling ties . . . . 93″
Placing rails . . . . 45″
Front clamps . . . . 20″

Some delays to the loading of trains caused by the shovel and the time consumed are as follows:

Blasting . . . . 42 minutes
Moving forward . . . . 85 minutes
Drilling . . . . 125 minutes
Clearing track . . . . 9 minutes

TRANSPORTATION

Train Number	Time for Round Trip from Shovel to Switch, Minutes	Time Waiting at Switch, Minutes	Time Traveling from Switch to Shovel, Minutes
11	11¾	9½	2½
1	15½	4	3¼
1	12¼	8	3
11	12½	Went to 1073	..
1	17	0	3
1	40½	0	2¼
12	24	0	2½
12	8	Went to 1073	..
1	10½	2½	2½
11	16½	Went to 1073	..
1	31½	Went to 1073	..
2	11	3½	2
Averages .	17.6	3.4	2.6

Average time for round trip = 23.6 minutes.

DINKEY No. 2—35-TON

	Minutes	Feet	Feet Per Minute
Waiting for empties	14	. . .	. .
Crusher to switch A	4	2050	510
Switch A to Shovel 1138 . .	1½	600	400
Shovel 1138 to crusher . . .	3½	2650	760
Round trip (exclusive of delays)	9	5300	590
Delays			
Letting loaded train out . .	1½	. . .	. .
Clearing track and blasting .	6	. . .	. .
Loading	16	. . .	. .
Round trip (including delays) .	32½	5300	163

Fig. 63. Bucyrus Shovel No. 1138

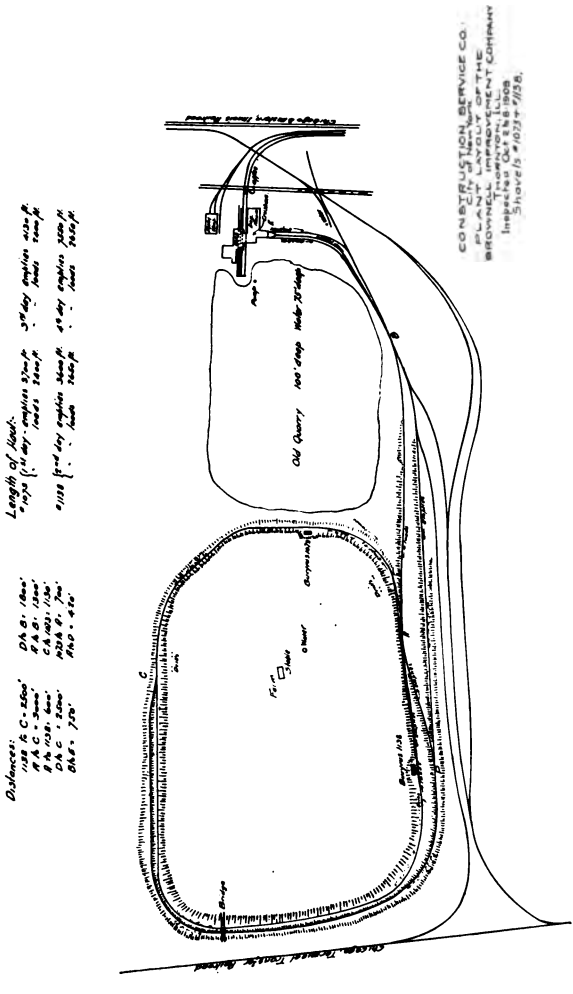

CONSTRUCTION SERVICE CO.
City of New York
PLANT LAYOUT OF THE
BROWNELL IMPROVEMENT COMPANY
THORNTON, ILL.
Inspected Oct 28-1908
Shovels #1073 + #1138.
Length of Haul:
Distances:
Old Quarry 100' deep Water 75' deep
Pump
Farm
Shack
Bridge
C

Fig. 64

Fig. 65. Two Views of Bucyrus Shovels Handling Crushed Rock. Brownell Improvement Company, Thornton, Ill.

REPORT No. 32 — SHOVEL No. 1073

INSPECTED OCTOBER 2-8, 1908

BROWNELL IMPROVEMENT CO.

THORNTON, ILL.

See Report 31, page 265, for Description, etc.

OBSERVATIONS GENERAL

Weight	95-ton
Gauge	Standard
Capacity of dipper	2.3 cubic yards
Kind of teeth	Manganese steel bases and points
Height of lift	12′
Height blocked up	0
Number of pitmen	4
Length of boom	30′
Length of dipper handle	18′
Height of boom above pivot	22′ 9″
Height of boom above shovel tracks	28′
Horizontal reach of boom	22′
Farthest dipper can reach to dump	27′
Highest dipper can reach to dump	17½′
Lowest dipper can reach to dig below shovel tracks	4′
Diameter of bull wheel	8½′
Height of dinkey tracks above shovel tracks	5½′
Distance inside dinkey track to inside shovel track	23½′
Depth of dipper (water measure)	46″
Depth of dipper including lip	55½″
Depth of dipper including teeth	72″

OBSERVATIONS—FIRST DAY

Cubic yards excavated	910
Number of cars loaded	227½
Capacity of cars (water measure)	5 cubic yards
Total distance moved forward during day	40′ 6″
Number of times moved forward during day	7
Maximum distance moved forward in one move	6′
Minimum time between beginning of one shovel move and beginning of next	53¾ minutes
Average time between beginning of one shovel move and beginning of next	81¼ minutes
Maximum time between beginning of one shovel move and beginning of next	116½ minutes
Minimum number of cars to one shovel move	20

OBSERVATIONS—FIRST DAY—*Continued*

Average number of cars to one shovel move	30.7
Maximum number of cars to one shovel move	40
Time between moves when maximum was loaded	108¼ minutes
Time between moves when minimum was loaded	53¾ minutes
Average time to load one train	12 minutes
Number of cars in train	10
Area of section	259 square feet
Height of face	18′
Number of times blasted bank	11
Average time to make one blast	10.1

Coal used, about 3 or 4 tons.

TIME STUDY. FIRST DAY

	Forenoon	Afternoon
Started work	7:42:30	12:28:00
Stopped work	12:06:30	6:00:00

Total time worked 264 + 332 minutes = 9 hours 56 minutes = 596 minutes.

These are the times when the observations began and ceased. The shovel worked 12 hours.

	Minutes	Seconds	Per Cent
Actual working	261	00	43.8
Spotting cars	4	30	0.8
Waiting for cars	(143	30)	(24.1)
Idle	30	. .	5.0
Oiling chain	25	30	4.3
Wiping engine, etc.	8	30	1.4
Blasting	68	00	11.4
Waiting for trains to be spotted	4	00	0.7
Leveling in front for moving forward	7	30	1.3
Moving shovel	80	15	13.5
Idle	(81	30)	(13.6)
Waiting for train to pull out .	1	00	0.2
Blasting (cars on hand) . .	42	45	7.1
Taking coal	19	. .	3.2
Putting two cars on track . .	7	30	1.3
Breaking boulder with sledge	6	30	1.1
Oiling machine	2	45	0.4
Minor repairs	2	. .	0.3
Miscellaneous delays . . .	(25	15)	(4.2)
Breaking bank	24	15	4.0
Handling boulder	1	. .	0.2
Total time under observation	596	00	100.0

Cost of Direct Labor (Loading) per Day	Standard Base
Runner	$5.00
Craneman	3.60
Fireman	2.40
4 pitmen	6.00
	$17 00

Cubic yards loaded on first day of observation 910
Based on observed performance, the cubic yards loaded per day

$$\text{of 10 hours} = 910 \times \frac{600}{596} = 916 \text{ cubic yards.}$$

$$\frac{\text{Cost direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$17.00}{916} = 1.86 \text{ cents per cubic yards.}$$

	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to waiting for blasters	74	30	12.5	0.232	0.232
Charge to loading					
1. Actual loading . . .	261	..	43.8	0.815	1.139
2. Delays					
a Moving up	80	15	13.5	0.251	
b Miscellaneous . . .	23	45	3.9	0.073	
Charge to transporting and dumping					
1. Waiting for cars . .	149	00	25.0	0.465	0.489
2. Miscellaneous . . .	7	30	1.3	0.024	
	596	00	100.0	....	1.860

Dipper Performance		Minimum	Average	Maximum	No of Obser-vations
Digging . . .	Time in Seconds	2.5	4.8	9.0	81
Swinging loaded		2.5	4.6	9.0	76
Swinging loaded		1.0	3.9	7.0	68
Falling empty .		2.7	3.8	7.0	69
Time to fill and load one dipperful . .		8.7	17.1	32.0	..

Time for a complete swing

	Minimum	Average	Maximum	No. Obs.	No. Attempts
Seconds . . .	15.5	19.5	29.5	67	69

Number of observations less than 20″ = 45
Number of observations greater than 20″ = 17
Number of observations at 20″ = 5

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SOME OF THE DELAYS TO LOADING TRAINS, AND TIME CONSUMED

Shovel crew getting to work	3½ minutes
Blasting	43 minutes
Moving forward	52 minutes
Oiling machine	3 minutes
Breaking boulder with sledge	6½ minutes
Waiting for trains ahead to load	18 minutes
Shovel breaking bank	1½ minutes
Shovel taking coal	19 minutes

Some times on the various operations in moving forward were obtained and are as follows:

Moving	29½″, 32″, 15″
Screwing jacks and swinging	105″–75″
Leveling in front	12 minutes–1¾ minutes
Carrying and placing ties	23″–52″
Carrying and placing rails	45″–55″
Screwing rail clamps	50″–25″
Front clamps	50″–27″
Rear clamps	15″
Leveling rails	40″–57″
Placing bumper tie	5″

OBSERVATIONS—SECOND DAY

Number of cars loaded	225
Cubic yards excavated	900 (cars equal 4 yards, place measure)
Capacity of cars (water measure)	5 cubic yards
Total distance moved forward during day	44′ 6″
Number of times moved forward during day	8
Maximum distance moved forward in one move	6′
Average time between beginning of one shovel move and beginning of next	67½ minutes

OBSERVATIONS—SECOND DAY—*Continued*

Maximum time between beginning of one shovel move and beginning of next . . . . 80¾ minutes
Minimum time between beginning of one shovel move and beginning of next . . . . 50¾ minutes
Average number of cars to one shovel move 30
Maximum number of cars to one shovel move 34
Minimum number of cars to one shovel move 26
Times between moves when maximum was loaded, 76¾ minutes
Times between moves when minimum was loaded, 37 minutes
Average time to load on train: 12 minutes for 10-car trains; 19 minutes for 15-car trains.
Number of cars in train . . . . 10; 3 trains of 15 cars
Area of section . . . . 280 square feet
Height of face . . . . 20 feet
Number of times blasted bank 7
Average time to make one blast . . . . 7.7 minutes
Coal used, about 3 to 4 tons. Could not be ascertained accurately.
Water used could not be ascertained. Tank leaked.

TIME STUDY. SECOND DAY

	Forenoon	Afternoon
Started work	7:16:00*	12:00:00
Stopped work	12:00:00	6:50:00

Total time worked 284 Min. + 410 Min. = 694 min. = 11 hours 34 minutes.

*This is the time when the observation began. The crew started at 6:00.

	Minutes	Seconds	Per Cent
Actual working	272	00	39.2
Spotting cars	1	00	0.1
Waiting for cars	(122	15)	(17.6
Idle	56	30	8.1
Oiling chain	10	00	1.4
Blasting	34	30	5.0
Minor repairs	21	15	3.1
Moving shovel	76	15	11.0
Idle	(215	45)	(31.1)
Oiling crane engine . . .	4	00	0.6
Putting on oil cup . . .	3	15	0.5
Oiling chain	3	15	0.5
Minor repairs	3	00	0.4

	Minutes	Seconds	Per Cent
Blasting (cars on hand) . .	20	15	2.9
Getting up steam	46	30	6.7
Repairing safety valve. . .	118	30	17.1
Getting ready to dig . . .	2	00	0.3
Taking coal	10	00	1.4
Repairing water pipe . . .	5	00	0.7
Miscellaneous delays			
Breaking bank	6	45	1.0
Total time under observation .	694	00	100.0

Cubic yards loaded on second day of observation . . . 900

Based on observed performance, the cubic yards loaded per day of 10 hours $= \frac{900 \times 600}{694} = 778.$

$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$17.00}{778} = 2.18$ cents per cubic yard.

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to waiting for blasters	29	00	4.2	0.092	0.092
Charge to loading					
1. Actual loading . .	272	00	39.2	0.854	
2. Delays					
a Moving up . . .	76	15	11.0	0.240	1.702
b Repairs	137	00	19.7	0.429	
c Miscellaneous . .	56	30	8.2	0.179	
Charge to transporting and dumping					
1. Waiting for cars .	123	15	17.7	0.386	0.386
	694	00	100.0	. . .	2.180

Dipper Performance		Minimum	Average	Maximum	Number of Observations
Digging	Time in Seconds	2.5	5.9	15.5	75
Swinging loaded . .	Time in Seconds	3.5	6.2	10.5	51
Swinging empty . . .	Time in Seconds	2.5	4.3	7.5	47
Falling empty . . .	Time in Seconds	2.5	4.1	7.0	61
Time to fill and load one dipperful . . .	Time in Seconds	11.0	20.5	40.5	..

Time for a complete swing

	Minimum	Average	Maximum	No. of Obs.	No. of Attempts
Seconds	14	23.4	43¼	46	49

Number of observations less than 20 seconds = 19
Number of observations greater than 20 seconds = 25
Number of observations at 20 seconds = 2

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SOME CAUSES OF DELAYS TO THE LOADING OF TRAINS AND THE TIME CONSUMED

	Delays	Minutes
Oiling chains	1	3¼
Waiting for train ahead to load	5	33½
Minor repairs to shovel	1	1¼
Blasting	3	31¼
Getting up steam	4	41¾
Moving forward and waiting for train ahead to load	1	29
Moving forward	3	31¾
Putting on oil cup	1	3¾
Engine getting ready to dig	1	¾
Oiling crane engine	1	4

Some times on the various operations in moving forward were obtained and are as follows:

Carrying and placing rails . . . . 43″–35″–47″–57″
Bolts and plates . . . . 35″–65″–60″
Front clamps . . . . 35″–33″–25″–55″
Bumper tie . . . . 10″–5″
Moving . . . . 21″–15″–23″–17″
Screwing jack, placing jack blocks and swinging . 2′ 15″, 1′ 40″, 1′ 24″, 3′ 28″
Leveling rock service in front for ties . 3 minutes, 6′ 30″-6′ 30″
Unscrewing jacks . . . . 23″
Unbolting rails in rear . . . . 60″–25″
Carrying rails from rear to alongside jacks . . . . 25″
Carrying ties from rear to front . . . . 2′ 31″
Leveling ties . . . . 26″–1′ 45″
Leveling rails . . . . 25″–200″
Clamps and blocks (rear of front truck) . . . . . 1′-35″–35″

Train Number	Times for Round Trip Minutes	Engine Number	Time from Shovel to Stopping Place	Time Waiting
11	28	1	13	30
11	20½	11	17	29
2	27	10	20	16
2	26	11	33	14
11	30	10	24	35
2	32	10	24	6
11	20	12	29	17
2	18	1	30	8
2	24			
11	25			
2	25	Averages	23.8	22
11	24½			
	300			
Average	25			

DINKEY No. 12—35-TON

	Minutes	Feet	Feet Per Minute
Crusher to shovel	7	4130	590
Loading	10½	. . .	. .
Shovel to switch	2	700	350
Switch to top of grade . . .	2	1000	500

DINKEY No. 10—35-TON

	Minutes	Feet	Feet Per Minute
Shovel to switch A	2	700	350
Switch A to crusher	3	2050	680
Switching	1½	. . .	. .
Crusher to switch C	5	5050	1010
Switch C to shovel No. 1138 .	3¾	2500	670
Shovel 1138 to crusher . . .	4½	2650	590
Round trip (exclusive of delays)	13¼	10200	770
Delays—Waiting for empties .	2	. . .	. .
Loading	28½	. . .	. .
Round trip (including delays) .	41¾	10200	245

DINKEY No. 1—35-TON

	Minutes	Feet	Feet Per Minute
Crusher to shovel No. 1073 .	8	4130	515
Shovel No. 1073 to switch A .	3	700	235
Switch A to crusher	2½	2050	820
Round trip (exclusive of delays)	13½	6880	510
Delays—Loading	10½	. . .	. .
Round trip (including delays) .	24	6880	290

REPORT No. 33 — SHOVEL No. 1096

INSPECTED JULY 27, 28, 1909

D., L. & W. CUT-OFF

NEAR JOHNSONBURG, N. J.

LOCATION AND MATERIAL The contractor for section No. 5, D., L. & W. cut-off, is the Hyde-McFarlin-Burke Company. This section is located in slate and limestone and is about three miles long, being about equally divided between cut and fill. Figs. 66 and 67 give an idea of the nature of the material in which No. 1096 and No. 1097 have cut through. This, however, was not the same as during our inspection, at which time the digging was easy and no time was spent in handling boulders, although on the second day (No. 1096) 19 minutes (total of three times) was spent in blasting a portion of a projecting ledge.

SHOVELS These two shovels are exactly alike. They weigh 70 tons, have standard gauge railway car trucks, and all steel boom and dipper handles, the former being of the lattice type. For the purpose of

Fig. 66

Fig. 67. View Showing Materials Encountered on D., L. & W. R. R. Near Johnsonburg, N. J.

Fig. 68

Fig. 69. Views Showing Method of Moving Back Shovel on D., L. & W. R. R. Near Johnsonburg, N. J.

Fig. 70. View Showing Device for Turning Cars on D., L. & W. R. R. Near Johnsonburg, N. J.

drilling holes for small blasts these machines are fitted with a small air compressor and tank. The compressor is located in the rear left-hand corner of the shovel and takes up a space about 6 feet high by one foot in diameter. The jacks fold against the A frame.

These shovels have been in use constantly on this work, and in some very hard digging, for just about a year, but show no wear.

An attempt was made to get the angle that the dipper makes with the vertical when the dipper handle is horizontal. Any such measurements to be of any use must be exact, as the variations in the angle would be so small that rough figures would be misleading. In general the dippers were at the same angle on each shovel,

although that on No. 1096 may have been a trifle greater.

These shovels have the lever device for dropping the ashes and turning the grate.

ARRANGEMENT The track arrangement on this job, because of its extent, circuitous route, and, in spite of the uneven country, its splendid facilities for serving cars to the shovel, is of special interest. The sketch shows accurately the arrangement and gives the grades and distances. All distances shown were measured, and all grades were obtained by a hand level and by pacing the distance. The maximum grade against the empties was 5.8 per cent, and it was observed that the dinkeys could only get up this by acquiring plenty of speed beforehand, or else by applying the brakes and shutting off steam every time the wheels slipped. On the sketch are indicated the direction of traffic and location of the grades.

TRANSPORTATION With the dump 1¾ miles from the shovels, and two shovels working, the subject of transportation becomes of vital importance. For this reason a detailed study of the time for a round trip together with the time and causes of delays was made.

Vulcan dinkeys are used, and the cars, which are side dump on one side only, were made by the South Baltimore Car & Foundry Company, Curtis Bay, Baltimore, Md. One of the illustrations (Fig. 70) shows the device for turning the cars when the fill must be made on the opposite side.

MOVING BACK On the second day of our inspection, shovel No. 1097 was moved back 1063 feet, and on the fourth day, shovel No. 1096 was

moved. The method employed for moving both shovels is plainly shown in the illustrations (Figs. 68 and 69), and as it was somewhat different from others that have been observed, it will bear some description. Two horses and sixteen men were used, eight lengths of 30 feet 60-pound rail and about one hundred ties, besides bridles, spikes, etc. The shovel is moved back two rail lengths at a time, the forward rails and ties being taken up and hauled by the horses to the rear, where the laborers lift them into place. Two men stay in front to unbolt as soon as the shovels move back, two others take up the ties as the horses haul away the rails. One man is required to follow the chain used for hauling the ties to see that it does not get caught in an obstruction, it being apparently too heavy to throw over a horse's back. Four men are kept in the rear to lay the ties as they come in, and the remaining men go where instructed. Eight men are required to lift each rail into place. The bridles are carried forward by the men, or else laid among the ties that the horse draws. There are enough extra ties to support the first rails that are brought, and these are laid while the shovel is moving, so that there is no delay when the rails are taken up.

CONTRACTOR'S METHODS The form submitted herewith is used for labor distribution. It fails, however, in that it does not show (and the contractor does not know) on what part of the work the men are engaged in making repairs.

OBSERVATIONS—GENERAL

Capacity of dipper	2½ yards
Kind of teeth on dipper	Manganese steel
Height blocked up	0
Weather, clear.	
Maximum height dipper can reach to dump	18′
Length of dipper handle	18′ 6″
Length of boom	28.5′
Maximum distance dipper can reach to dump	28.8′
Maximum distance dipper can reach to dig	30′

OBSERVATIONS—GENERAL—*Continued*

Greatest depth dipper can dig	7′
Diameter of bull wheel	8′
Capacity of cars, water measure	4.00 cubic yards
Number of cars in train	9 and 10
Height of cars above their track	5′ 8″
Length of haul (approximate)	7500′
Length of runaround	3.61 miles
Weight of dinkeys	18 tons
Style of car	Side dump on one side only
Height of top of cars above shovel track	15.2′
Gauge of dinkey tracks	Narrow
Number of trains	7
Average time for round trip	45 minutes
Maximum grades for loads	4.0 per cent and 3.0 per cent
Maximum grades for empties	plus 5.8 per cent–2 per cent
Complete trains for grades.	
Time traveling to dump	18.8 minutes
Time traveling from dump to shovel	17.7 minutes
Average time to dump cars	4.9 minutes
Distance inside dinkey track to inside shovel track	23.4′

OBSERVATIONS—FIRST DAY

Swings per minute	2.56
Number of cars loaded	468
Cubic yards excavated	1685
Number of times moved forward	16
Average distance moved each time	5′ 11″
Total distance moved during day	95′
Time in minutes to load one cubic foot with dipper	.0086
Time shovel is interrupted while spotting one car	.014 minute
Time shovel is interrupted to change trains	9 minutes
Minutes per working day less time for accidental delays	608
Coal used	3.16 tons
Area of section	559.3 square feet
Height of face	14′ (average)
Number of times blasted bank	1
Average time to move forward once	7.34 minutes
Average time to move forward one foot	1.28 minutes
Average time to load one car	0.929 minute
Pounds of coal per cubic yard excavated	3.75
Maximum distance moved forward in one move	7′
Average time for one swing	23.4 seconds
Average time between beginning of one shovel move to beginning of next	38.0
Number of cars for one shovel move	29.1

TIME STUDY

	Forenoon	Afternoon
Started work	6:29:00	12:25:00
Stopped work	11:53:30	5:56:00

Min. Sec. Min. Min. Sec.

Total time worked 324 30 + 331 = 655 30 = 10 hours 55 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	434	54	66.3
Spotting cars	6	36	1.0
Waiting for cars	9	00	1.4
Moving shovel	117	30	17.9
Idle	(31)	(30)	(4.8)
Repairing chain	25	30	3.8
Jacking	3	..	0.5
Oiling up	3	..	0.5
Miscellaneous delays	(56)	..	(8.6)
Clearing way	43	..	6.6
Placing car on track	13	..	2.0
Total time under observation	655	30	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	\$5.00
Craneman	3.60
Fireman	2.40
8 pitmen	12.00
	\$23.00

Number of cubic yards loaded during first day of observation, 1685. Based on above performance the cubic yards loaded per day of

$$10 \text{ hours} = 1685 \times \frac{600}{655.5} = 1542.$$

$$\frac{\text{Cost of direct labor per day}}{\text{Number of cubic yards per day}} = \frac{\$23.00}{1542} = 1.49 \text{ cents per cubic yard.}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loading					
1. Actual loading	434	54	66.3	0.988	1.326
2. Delays					
a Moving up	117	30	17.9	0.266	
b Repairs	25	30	3.8	0.057	
c Miscellaneous	6	00	1.0	0.015	
Charge to transporting and dumping					
1. Waiting for cars	15	36	2.4	0.036	0.164
2. Miscellaneous	56	..	8.5	0.128	
	655	30	100.0	. . .	1.49

Analysis of complete dipper swing

		Minimum	Average	Maximum	No. of Obs.
Digging	Time in Seconds	7	17.3	39	31
Swinging loaded	Time in Seconds	4.5	8.7	16	31
Swinging empty	Time in Seconds	2	4.6	6	31
Falling	Time in Seconds	2	3.5	22	31
Time to fill and load one dipperful		15.5	34.1	83	31

Number of attempts to fill dipper 65
Number of complete dipperfuls 31

Dipper efficiency, 47.7%.

Time for complete swing

	Minimum	Average	Maximum	Number of Observations
Seconds	17	23.4	34	31

Number of swings per minute

Minimum	Average	Maximum	Number of Observations
1.8	2.56	3.5	31

COST OF MOVING BACK. STANDARD BASIS

Runner	for 1.25 days . @	$5.00	$ 6.25
Craneman	for 1.25 days . @	3.60	4.50
Fireman	for 1.25 days . @	2.40	3.00
14 laborers	for 13½ hours @	0.15	28.35
2 drivers	for 13½ hours @	0.15	4.05
2 horses	for 1.23 days . @	1.50	3.69
4 pipe fitters	for 1.25 days . @	2.00	10.00
Coal	2 tons . . . @	3.50	7.00
Oil and waste		. . .	1.00
Shifting track:			
5 laborers	for 13½ hours @	0.15	10.12
9 laborers	for 11 hours . @	0.15	14.85
1 foreman	for 1.25 days . @	2.00	2.50
Total cost to move back		. . .	$95.31

Total distance moved . . . . 1063 feet
Total time required . . . . 1.25 days
Total number of employed 46*
Cost per foot moved . . . . 9.0 cents
Cost per foot per man . . . . 0.196 cent

* Includes shifting track; one horse taken as equivalent of four men.

OBSERVATIONS—SECOND DAY

Swings per minute 885
Number of cars loaded 266
Cubic yards excavated 958
Number of times moved forward 12
Average distance moved each time . . . . 6′ 3″
Total distance moved forward during day . . . . 75′ 6″
Time in minutes to load one cubic foot with dipper . . .013
Time shovel is interrupted while spotting one car . . .019 minute
Minutes per working day, less time for accidental delays . 617¼
Shovel expenses in cents, one day, not including superintendent and overhead or preparatory charges 3349

OBSERVATIONS—SECOND DAY—*Continued*

Coal used	2.42 tons
Area of section	467 square feet
Height of face	12.7′
Number of times blasted bank	3
Average time to move forward once	9.083 minutes
Average time to move forward one foot	1.311 minutes
Average time to load one car	1.170 minutes
Pounds of coal used per cubic yard excavated	5.05

Total cost to excavate, transport and spread one cubic yard, 12.26 cents.

Number of cars for one shovel move	22.2
Maximum distance moved forward in one move	6′ 6″
Average time for one swing	23.3 seconds
Average time between beginning of one shovel move and beginning of next	55.1 seconds

TIME STUDY

	Forenoon	Afternoon
Started work	6:30	12:35
Stopped work	12:06	6:05

Total time worked 336 minutes + 330 minutes = 666 minutes = 11 hours 6 minutes.

	Minutes	Seconds	Per Cent
Actual working	311	15	46.7
Spotting cars	5	00	0.8
Waiting for cars	148	00	22.2
Moving shovel	109	00	16.4
Idle	(68	15)	(10.2)
Blasting	19	30	2.9
Repairing chain	10	00	1.5
Trouble with water pipe	38	45	5.8
Miscellaneous delays			
Clearing track	24	30	3 7
Total time under observation	666	00	100.0

Number of cubic yards loaded on second day of observation, 958. Based on the above performance, the number of cubic yards loaded per day of 10 hours $= 958 \times \frac{600}{666} = 865$.

$$\frac{\text{Cost of direct labor per day}}{\text{Number of cubic yards per day}} = \frac{\$23.00}{568} = 2.66 \text{ cents per cubic yard.}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loosening or breaking	19	30	2.9	0.077	0.077
Charge to loading					
1. Actual loading . . .	311	15	46.7	1.243	1.873
2. Delays					
a Moving up	109	00	16.4	0.436	
b Repairs	10	00	1.5	0.040	
c Miscellaneous . . .	38	45	5.8	0.154	
Charge to transporting and dumping					
1. Waiting for cars . . .	153	00	23.0	0.612	0.710
2. Miscellaneous . . .	24	30	3.7	0.098	
	666	00	100.0		2.660

Analysis of complete dipper swing

		Minimum	Average	Maximum	No. of Obs.
Digging	Time in Seconds	4	10.4	25½	26
Swinging loaded . .		4	6.9	16	23
Swinging empty . .		3	4.8	9	14
Falling		3	6.4	7	12
Time to fill and load one dipperful		14	28.5	57½	..

Number of attempts to fill dipper 33
Number of complete dipperfuls 26
Dipper efficiency = 78.8 per cent.

Time for a complete swing

	Minimum	Average	Maximum	Number of Observations
Seconds	12½	23.3	34	16

Number of swings per minute

Maximum	Average	Minimum	Number of Observations
4.8	2.57	1.77	16

It is our understanding that the number of cars loaded daily for the months of 1909, as designated, is as follows:

	February	March	April	May	June	July
1	112	260	216	206	200	320
2	262	216	168	Sunday	200	424
3	262	216	40	200	216	477
4	176	104	Sunday	200	80	Sunday
5	168	144	184	206	200	459
6	216	184	144	210	Sunday	387
7	Sunday	Sunday	170	200	234	189
8	208	168	165	216	152	414
9	176	216	150	Sunday	216	450
10	56	208	192	224	50	432
11	147	192	Sunday	168	. .	Sunday
12	206	152	132	176	. .	. .
13	184	168	. .	200	Sunday	459
14	Sunday	Sunday	. .	16	. .	415
15	144	128	56	160	. .	351
16	102	208	190	Sunday	. .	396
17	128	184	180	. .	. .	200
18	240	216	Sunday	256	. .	Sunday
19	Moved	200	202	262	. .	405
20	Back	232	96	280	Sunday	474
21	Sunday	Sunday	252	208	. .	410
22	105	168	326	160	160	371
23	136	156	140	Sunday	280	282
24	120	. .	180	240	264	318
25	232	192	Sunday	216	248	Sunday
26	232	224	160	160	256	363
27	232	156	105	272	Sunday	. .
28	Sunday	Sunday	235	160	200	. .
29	. .	175	200	240	376	. .
30	. .	184	140	Sunday	312	. .
31	. .	165	. .	208	. .	. .
Totals	3844	4816	4029	5044	3644	. .
Average	175	185	168	202	214	381 [Not Complete Mo.]

HYDE-McFARLIN-BURKE COMPANY
DAILY TIME REPORT

SHOVEL NO. __________ ENGINEER __________ ______________________

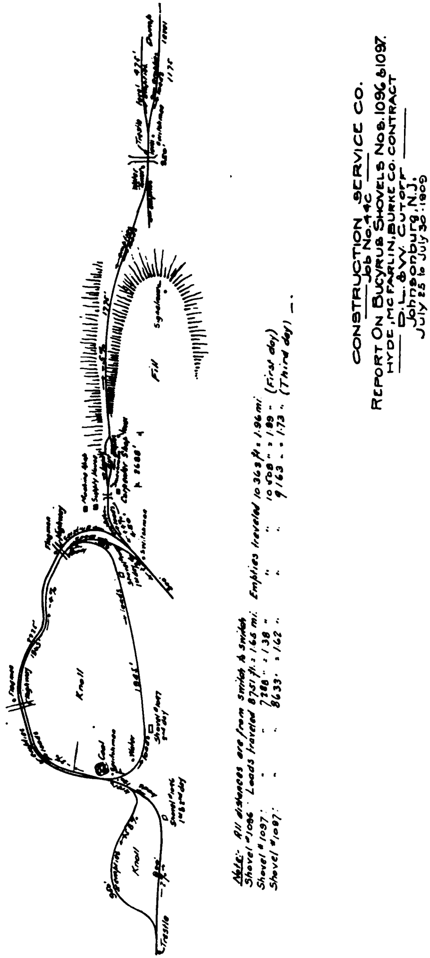
NAME OF CUT ______________________

	NO.	HRS.	RATE	AMOUNT	TOTAL
GENERAL WORK					
Superintendent					
Timekeeper					
Watchman					
S.S. EXPENSE					
S.S. Engineer					
Craneman					
Fireman					
Laborers					
TRAINMEN					
Locomotive Eng'r					
Brakeman					
Switchman					
Oiler					
Sandman					
Laborers					
TRACK					
Foreman					
"					
Waterboy					
Laborers					
TRESTLE					
Foreman					
Carpenters					
"					
Laborers					
DUMP					
Foreman					
"					
Waterboy					
Laborers					
DRILL & BLAST					
Foreman					
Drillers					
Powderman					
Laborers					
REPAIRS					
Mechanic					
Blacksmith					
"					
Helpers					
"					
Carpenters					
"					
Laborers					
FORWARD					

	NO.	HRS.	RATE	AMOUNT	TOTAL
BRT. FORWARD					
HAND EXCAV.					
Foreman					
"					
Waterboy					
Laborers					
DITCHING					
Foreman					
"					
Waterboy					
Laborers					
CLEANING					
Foreman					
"					
Waterboy					
Laborers					
WATER SUPPLY					
Pumpman					
Pipeman					
TEAMS					
Teams					
Teamster					
Helper					
EXTRA WORK					
DAY'S EXPENSE					
PREVIOUS					
TOTAL					

Earth Moved ______	*Rock Moved* ______
Previous ______	*Previous* ______
Total ______	*Total* ______
Large Cars ______	*Yards per Large Car* ______
Previous ______	*Yards per Small Car* ______
Total ______	*Total* ______
Small Cars ______	*Shovel Worked* ______ *hrs.*
Previous ______	*Correct:*
Total ______	______ Superintendent.
Trains ______	______ Timekeeper.

DISTRIBUTE ENTIRE LABOR FOR THE DAY UNDER HEADS NOTED HEREON


CONSTRUCTION SERVICE CO.
Job No. 44c
REPORT ON BUCYRUS SHOVELS NOS. 1096 & 1097.
HYDE, MCFARLIN, BURKE CO. CONTRACT
D.L.&W. CUTOFF
Johnsonburg, N.J.
July 25 to July 30: 1909
Note: All distances are from switch to switch
Shovel #1096 Loads traveled 8751 ft. = 1.65 mi. Empties traveled 10363 ft. = 1.96 mi.
Shovel #1097: " " 7288 " = 1.38 " " " 10508 " = 1.99 " (First day)
Shovel #1097: " " 8633 " = 1.62 " " " 9163 " = 1.73 " (Third day)
Fill
Signalman
Knoll
Knoll
Coal
Water
Trestle
Trestle
Dump

REPORT No. 34 — SHOVEL No. 1097

INSPECTED JULY 26 AND 28, 1909

D., L. & W. CUT-OFF

NEAR JOHNSONBURG, N. J.

SHOVEL No. 1097 is located at Section No. 5 of the D., L. & W. cut-off, near Johnsonburg, N. J. It is working with and is just like shovel No. 1096, under the report of which will be found a complete description of both. See page 286.

OBSERVATIONS—GENERAL

Weight	70 tons
Gauge	Standard
Capacity of dipper	2½ cubic yards
Kind of teeth on dipper	Manganese steel
Maximum height dipper can reach to dump	15′
Length of dipper handle	18′ 6″
Length of boom	28′
Maximum distance dipper can reach to dump	28′
Capacity of cars, water measure	4.00 cubic yards
Capacity of cars, loose	3.6 yards
Number of cars in train	9 and 10
Height of cars above their own tracks	5′ 8″
Length of haul	7500′

Length of runaround, 1st day, 3.37 miles; 2d day, 3.35 miles

Weight of dinkeys	18 tons

Style of car, side dump on one side only.

Height of top of cars above shovel track, 14′ 1st day; 15′ 2d day.

Gauge of dinkey tracks	Narrow
Number of trains	7
Average time for round trip	45 minutes
Maximum grades for loads	4.0 per cent.
Maximum grades for empties	5.8 per cent.

Complete trains for grades? Yes.

Time traveling to dump	18.8 minutes
Time traveling from dump to shovel	17.7 minutes
Time to dump cars	4.9 minutes

Distance from inside shovel track to inside dinkey track, 16.5′ 1st day.

Distance inside shovel track to inside dinkey track, 22.8′ 2d day

OBSERVATIONS—FIRST DAY

Number of cars loaded	296
Average time to load one car	0.935 minute
Cubic yards, place measure	1065 yards
Total distance moved forward during day	79½′
Average time for one move	6.5 minutes
Average time to move one foot	1 minute
Maximum distance moved forward at one time	7′ 3″
Average distance moved forward each time	6½′

Average time beginning of one move and beginning of next, 41.6 minutes.

Number of cars to one shovel move	24.7
Time to load one cubic foot with dipper	.010 minute
Time shovel is interrupted while spotting one car	.006 minute
Time shovel is interrupted to change trains	114 minutes
Minutes per working day less time for accidental delays	518
Area of section	210 square feet
Average height of face	4½′
Number of times blasted bank	0
Coal used	2.3 tons
Pounds of coal per cubic yard excavated	4.3

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	6:24	12:25
Stopped work	11:54	3:33

Total time worked 330 + 188 minutes = 518 minutes = 8 hours 38 minutes.

	Minutes	Seconds	Per Cent
Actual working	276	48	53.4
Spotting cars	1	42	0.3
Waiting for cars	114	00	22.0
Moving shovel	79	00	15.3
Miscellaneous delays	(46	30)	(9.0)
Clearing away	43	30	8.4
Breaking bank	1	00	0.2
Placing car on track	2	00	0.4
Total time under observation	518	00	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
8 pitmen	12.00
	$23.00

Cubic yards loaded on first day of observation 1065
Based on the above performance the cubic yards loaded per day

$$\text{of 10 hours} = 1065 \times \frac{600}{518} = 1235$$

$$\frac{\text{Cost of direct labor per day}}{\text{Number of cubic yards per day}} = \frac{\$23.00}{1235} = \text{1.86 cents per cubic yard}$$

Process Analysis	Time Min.	Time Sec	Per Cent	Cost per Yard in Cents	Total Cost
Charges to waiting for blasters	1	00	0.2	0.004	0.004
Charge to loading					
1. Actual loading	276	48	53.4	0.993	1.278
2. Delays					
a Moving up	79	00	15.3	0.285	
Charge to transporting and dumping					
1. Waiting for cars	115	42	22.3	0.415	0.578
2. Miscellaneous	45	30	8.8	0.163	
	518	00	100.0		1.860

OBSERVATIONS—SECOND DAY

Swings per minute 2.6
Number of cars loaded 270
Cubic yards excavated 972
Number of times moved forward 19
Average distance moved forward each time . . . . . 6′ 2″
Total distance moved forward during day . . . . . 117′ 3″
Time to load one cubic foot with dipper . . . .00791 minute

OBSERVATIONS—SECOND DAY—*Continued*

Time shovel is interrupted while spotting one car .0315 minute
Time shovel is interrupted to change trains . . . 171 minutes
Time moving forward . . . . 198½ minutes
Minutes per working day less time for accidental delays . 646½
Coal used . . . . 3.18 tons
Area of section . . . . 0 to 276 square feet
Height of face . . . . 0 to 9′
Number of times blasted bank 0
Average time to move forward once . . . . . 10.447 minutes
Average time to move forward one foot . . . 1.693 minutes
Average time to load one car . . . . 0.854 minute
Pounds coal used for cubic yard excavated 6.55
Number of cars for one shovel move 14.2
Maximum distance moved forward in one move . . . 6′ 10″
Average time for one swing . . . . 0.39 minute
Average time between beginning of one shovel move and next, 34.8 minutes.

TIME STUDY—SECOND DAY

	Forenoon	Afternoon
Started work	6:25	12:26
Stopped work	11:58	5:55

Total time worked 333 + 329 minutes = 662 minutes = 11 hours 2 minutes.

	Minutes	Seconds	Per Cent.
Actual working	230	30	34.8
Spotting cars	8	30	1.3
Waiting for cars	171	..	25.8
Moving shovel	198	30	30.0
Idle	(32)	..	(4.8)
Car off track	5	..	0.7
Removing rails in front of shovel	14	..	2.1
Repairing steam pipe	13	..	2.0
Miscellaneous delays	(21	30)	(3.3)
Clearing way	15	..	2.3
Car off and shifting dinkey track	6	30	1.0
Total time under observation . .	662	...	100.0

Cubic yards loaded on second day of observation . . . 972
Based upon the above performance the cubic yards loaded per

$$\text{day of 10 hours} = 972 \times \frac{600}{662} = 881.$$

$$\frac{\text{Cost of direct labor per day}}{\text{Number cubic yards per day}} = \frac{\$23.00}{881} = 2.61 \text{ cents per cubic yard}$$

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total
Charge to loading					
1. Actual loading . .	230	30	34.8	0.908	
2. Delays					
a Moving up . . .	198	30	30.0	0.783	1.798
b Repairs	13	00	2.0	0.052	
c Miscellaneous . .	14	00	2.1	0.055	
Charge to transporting and dumping					
1. Waiting for cars . .	179	30	27.1	0.708	0.812
2. Miscellaneous . . .	26	30	4.0	0.104	
	662	00	100.0	. . .	2.610

		Minimum	Average	Maximum	No. of Obs.
Digging	Time in Seconds	5	7.6	12½	20
Swinging loaded. . .	Time in Seconds	3½	8.4	12½	18
Swinging empty . . .	Time in Seconds	4½	5.7	7	15
Falling	Time in Seconds	2½	5.3	6	12
Time to fill one dipperful . . .		15½	27.0	38	..

Number of attempts to fill dipper 26
Dipper efficiency . . . . 76.9 per cent

Time for a complete swing

	Minimum	Average	Maximum	Number of Observations
Seconds	19	23.2	26½	14

Number of swings per minute

Minimum	Average	Maximum	Number of Observations
2.26	2.59	3.16	14

Cost of Moving Back		Standard Basis	
Runner for 1.59 days	@	$5.00	$7.95
Craneman for 1.59 days	@	3.60	5.72
Fireman for 1.59 days	@	2.40	3.82
14 laborers for 17½ hours	@	0.15	36.75
2 drivers for 17½ hours	@	0.15	5.25
2 horses for 1.59 days	@	1.50	4.77
4 pipe fitters for 1.59 days	@	2.00	12.72
Coal, 2 tons		3.50	7.00
Oil and waste		...	1.00
Shifting track			
10 laborers for 17½ hours	@	0.15	26.25
1 foreman for 1.59 days	@	2.00	3.18
Tearing down trestle			
6 laborers for 5½ hours	@	0.15	4.95
2 horses for ½ day	@	1.50	1.50
Coal, 2 tons	@	3.50	7.00
Oil and waste		...	1.00
Total cost to move back		...	$128.86

Total distance moved	820′
Total time actually moving	1 day
Total time idle	1.59
Number of men employed	60*
Cost per foot moved	15.71 cents
Cost per foot per man	.262 cent

* Includes pulling down trestle, shifting track, and one horse equal to four men.

It is our understanding that the following represents the number of cars loaded daily, for the months shown, 1909:

	February	March	April	May	June	July
1	152	192	192	240	344	122
2	272	176	184	Sunday	224	190
3	136	168	208	264	304	198
4	192	40	Sunday	. .	224	Sunday
5	224	160	200	216	240	99
6	160	160	168	248	Sunday	144
7	Sunday	Sunday	152	240	232	144
8	200	168	160	248	296	189
9	136	160	200	Sunday	224	198
10	28	248	200	288	208	225
11	200	280	Sunday	304	176	Sunday
12	216	256	192	288	248	. .
13	184	216	200	200	Sunday	. .
14	Sunday	Sunday	200	212	208	. .
15	224	144	. .	336	272	109
16	88	88	192	Sunday	328	189
17	184	248	240	320	136	189
18	168	216	Sunday	272	184	Sunday
19	144	216	184	232	168	224
20	184	200	72	272	Sunday	153
21	Sunday	Sunday	216	176	184	122
22	248	240	232	248	168	248
23	152	264	240	Sunday	176	270
24	176	256	232	176	184	262
25	200	248	Sunday	160	192	Sunday
26	272	. .	248	316	200	. .
27	248	240	288	73	Sunday	. .
28	Sunday	Sunday	288	216	152	. .
29	. .	264	200	320	170	. .
30	. .	216	208	Sunday	180	. .
31	. .	184	. .	376	. .	. .
Totals	4388	5248	5096	6241	5622	. . .
Average	183	202	204	250	216	. . .

Dinkey Number	From	To	Time	Distance Feet	Rate Feet per Minute	Delays Minutes	Time for Trip	Per Cent of Delays to Total Time	Causes of Delays
3	Switch at dump	Water tank	1	250	250.0	2	P M 2:26	. . .	Taking water
3	Water tower	Station 710	2	1775	887.5	½	2:54	. . .	Switching
3	Station 710	Arch	3½	2688	768.6	3½	. . .	. . .	Waiting for No. 2 to pass.
3	Arch	500 feet from coal pile	4½	2200	488.8	8½	. . .	. . .	Two empties ahead
3	500 feet from coal pile	Coal pile	1½	500	333.3	. .	. . .	. . .	Took on coal
			12½	. . .	Av.545.5	14½	28	51.8	
3	Shovel 1097	Arch	8¼	1525	184.8	. .	. . .	. . .	
3	Arch	Station 710	5¾	2688	467.4	. .	4:23	. . .	
3	Station 710	Dump	7	3200	457.1	1	5:16	. . .	Switching
3	Dump	Switch at dump	1	1175	1175.0	6	. . .	. . .	Dumping
3	Switch at dump	Water tower	¾	250	333.3	3¼	. . .	. . .	Waiting for train to pass.
3	Water tower	Station 710	2	1775	887.5	2	. . .	. . .	Taking water
3	Station 710	Arch	3	2688	896.0	. .	. . .	. . .	
3	Arch	Coal pile	5	2675	535.0	8	. . .	. . .	Repairs
			32¾	. . .	Av.617.0	20¼	53	38.2	

Dinkey Number	From	To	Time	Distance Feet	Rate Feet per Minute	Delays Minutes	Time for Trip	PerCent of Delays to Total Time	Causes of Delays
							P M		
1	Shovel 1097	Arch	7	1525	217.9	..	...	...	
1	Arch	Station 710	4¼	2688	632.4	..	2:32	...	
1	Station 710	Dump	1	3200	3200.0	4¼	4:52½	...	Dumping
1	Dump	Water tower	5	1425	285.0	5½	...	...	Taking water
1	Water tower	Side track	½	100	200.0	3	...	...	Waiting for train to pass
1	Side track	Station 710	2½	1875	750.0	..	...	...	
1	Station 710	Arch	3	2688	899.3	..	...	...	
1	Arch	Coal pile	5½	2675	486.3	..	...	...	
1	Coal pile	Shovel	½	300	600.0	98½	...	...	Two trains ahead
			29¼	...	Av.807.9	111¼	140½	79.2	
7	Shovel 1097	Arch	7	1525	217.9	..	...	...	
7	Arch	Station 710	4	2688	672.0	..	3:29	...	
7	Station 710	Dump	7	3200	457.1	..	5:37½	...	
7	Dump	Water tower	½	1425	2850.0	4½	...	...	Dumping
7	Water tower	Station 710	1¼	1775	1420.0	2¾	...	...	Taking water
7	Station 710	Arch	3½	2688	766.0	..	...	...	
7	Arch	Coal pile	4	2675	668.7	..	...	...	
7	Coal pile	Shovel	½	300	600.0	93½	...	...	
			27¾	...	Av.956.2	100¾	128½	78.4	

Dinkey Number	From	To	Time	Distance Feet	Rate Feet per Minute	Went to Shovel	Time Shovel to Shovel Minutes	Amount of Delays	Causes of Delays
10	1096	1097	74½	17914	240.5	1097	74½	..	
2	1096	coal	45	17202	382.3	1096	78¾	33¾	Held at switch, four trains ahead
9	1096	1097	..	17914	325.7	1097	55	..	
10	1097	1096	63	18996	301.5	1096	63	..	
9	1097	1097	49½	17796	359.5	1097	49½	..	
5	1096	coal	49	17202	351.0	1097	54	5	One train ahead
2	1096	coal	57½	17202	299.3	1097	63½	6	Train ahead
5	1097	1097	51½	17796	345.5	1097	51½	..	
3	1096	1096	62	19144	308.0	1096	62	..	
1	1097	1097	51	17796	349.7	1097	51	..	
7	1096	1096	60½	19144	316.4	1096	60½	..	
7	1096	coal	40	17202	430.5	1096	54	14	Shovel moving held switch
1	1097	1097	82	17796	217.0	1097	82	..	
2	1097	1097	45	17796	395.4	1097	45	..	
1	1096	1097	45½	17914	393.7	1097	45½	..	
3	1097	1096	48½	18996	391.6	1096	48½	..	
10	1096	1096	95	19144	201.5	1096	95	..	Cars off track at dump
1	1097	1097	94	17796	189.2	1097	94	..	Cars off track at dump
2	1096	1096	43½	19144	440.1	1096	43½	..	
9	1097	1097	59½	17796	299.1	1097	59½	..	
7	1096	1097	57½	17914	311.5	1097	57½	..	
5	1097	1097	70	17796	254.3	1097	70	..	

Minimum Rate in Feet per Minute 178.4
Average " " " " " 317¼
Maximum " " " " " 440.1

Minimum Time for Trip . . . . 45 minutes
Average " " " . . . . 61.7 minutes
Maximum " " " . . . . 95 minutes

Fig. 71. View of D., L. & W. R. R. Cut at Johnsonburg, N. J.

Fig. 72. Bucyrus Shovel No. 1097

REPORT No. 35 — SHOVEL No. 795

INSPECTED AUGUST 10, 1909

NEAR COLUMBIA, N. J.

LOCATION Shovels No. 795 and No. 875 (page 357) were working on section No. 7 of the D., L. & W. cut-off, near Columbia, N. J.

MATERIAL The material is a hard crystalline limestone, and on the day of inspection the shovel worked in this until 3:45 p. m., thereafter in earth. The limestone was well broken but mixed with some very large pieces. There are 291,166 cubic yards of earth and rock in this cut, according to the engineer's preliminary figures of which two-thirds or three-quarters are rock. The shovel had been working about six or eight weeks in this location.

It was noticed that the thrusting engine did not hold the dipper against the face of the rock properly, which was due to the fact that the boom engine of a 65-ton shovel with 7 x 7-inch cylinders was not adequate for rock excavation of this character. The 70-ton shovel, however, such as No. 875 with 8 x 8-inch cylinders on the boom engines, gave perfectly satisfactory results. The boom and dipper handle are made entirely of steel, the former being of the truss type.

TRANSPORTATION The cars were built by the Western Wheel Scraper Company. Some of them dump on both sides and some on one side only. They measure 110 x 83 x 19 inches and are 5 feet 6 inches above their tracks. When loaded with stone they average about 2½ yards. Three 18-ton Vulcan dinkeys are used at each shovel, with an extra,

one which during inspection held trains back in descending a steep grade ending in a sharp curve. In order to dump from the trestle it was necessary for the dinkey to run around the train, as they always pulled, instead of pushing, the cars when running loaded. This took from two to three minutes. Then, after dumping, it was necessary for the dinkey to switch back again, but as this was a flying switch very little time was lost. Under the observed conditions it was necessary for the dinkey to uncouple while the car next to it was loaded. The reason for such an arrangement appears to be in the fact that the cars ride better when being hauled than when pushed, and in this connection it should be remarked that the number of derailed cars was very small. The dinkeys maintained a steady pace that was not as fast as on some other jobs, but which made better time in the end because the chances for a car to jump were diminished.

OBSERVATIONS

Height of lift	7
Kind of teeth	Manganese steel
Height blocked up	1′
Length of boom	23′
Height of face	15′
Length of dipper handle	18′ 6″
Inside shovel track to inside dinkey track	20′
Reach of boom	14.8′
Height of point of boom above pivot of boom	18.3′
Dinkey tracks 16″ higher than shovel tracks.	
Diameter of bull wheel	7½′
Highest dipper can reach to dump	16′
Farthest dipper can reach to dump	28′

Dipper, 48″ deep; bottom to lip, 60″; bottom to point of teeth, 76″

OBSERVATIONS—*Continued*

Weather, clear.
Number of cars in one train 10
Height of cars above their track . . . . 5½′
Length of haul (approximate) . . . . 9000′
Length of runaround (approximate) . . . . 19,200′
Weight of dinkeys . . . . 18 tons
Gauge of dinkey track . . . . Narrow
Number of trains 3
Grades . . . . One of about 4 per cent for 300′
Full trains on grades, with extra dinkey to help.
Number of cars loaded . . . . . 206; 133 rock, 73 earth
Cubic yards excavated: 133 of rock at 2 yards = 266, and 73 of earth at 3.2 yards = 233; total, 499 cubic yards.
Total distance moved forward during day, 44.7′; 27.7′ of rock, 17′ of earth.
Number of times moved forward . . . . . 8; 5 rock, 3 earth
Maximum distance moved forward in one move, 5′ 11″; 5′ 11″ rock, 5′ 10″ earth.
Average time between beginning of one shovel move and beginning of next, 75.7 minutes.
Number of cars to one shovel move, 25.7; 73.7 rock, 49 earth; 26.6 rock, 24.3 earth.
Average time shovel is interrupted while spotting one car, .004 minute.
Minutes per working day, less time for accidental delays . . 589
Area of section . 325 square feet = when material was blasted
Height of face . . . . 14.5′; 14 rock, 15 earth
Coal used . . . . 2.83 tons

TIME STUDY

	Forenoon	Afternoon	
Started work	Rock 7:00	Rock 1:03	Earth 3:28
Stopped work	Rock 12:01	Rock 3:28	Earth 6:04

Total time worked:

	Min.	Min.	Min.	Hrs.	Min.	
Rock —	301 +	145 =	446 =	7	26	10 hours 2 minutes.
Earth —	156		=	2	36	

	Total Min.	Rock Min.	Per Cent	Earth Min.	Per Cent
Actual working	324	247.5	55.5	76.5	49.1
Spotting cars	1.0	0.5	0.1	0.5	0.3
Waiting for cars	49.5	34.5	7.7	15	9.6
Moving shovel	88.5	49.5	11.1	39	25.0
Idle	(91)	(76)	(17.1)	(15)	(9.6)
Blasting	84	72	16.2	12	7.7
Tightening bolts	3			3	1.9
Repairing dipper	4	4	0.9		
Miscellaneous delays	(48)	(38)	(8.5)	(10)	(6.4)
Clearing track	28.5	18	4.1	10	6.4
Moving boulder	6.5	6.5	1.5		
Putting car on track	6	6	1.3		
Tearing down bank	7	7	1.6		
Tot. time under observation	602	446	100.0	156	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
Coalman	1.50
	$21.50

Number of cubic yards of rock loaded during observation, 266. Based upon the above performance the number of cubic yards loaded per day of ten hours, $\frac{602 \times 266}{446} = 358$.

Cost of direct labor per day per cubic yard $\frac{\$21.50}{358} = 6.00$ cents per cubic yard.

Process Analysis—Rock	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loosening or breaking	85	30	19.3	1.158	1.158
Charge to loading					
1. Actual loading . . .	247	30	55.5	3.330	4.050
2. Delays					
a Moving up . . .	49	30	11.1	0.666	
b Repairs	4	00	0.9	0.054	
Charge to transporting and dumping					
1. Waiting for cars . .	35	00	7.8	0.468	0.792
2. Miscellaneous . . .	24	30	5.4	0.324	
	446	00	100.0	. . .	6.000

Number of cubic yards of earth loaded during observation, 233. Based upon above performance the cubic yards loaded per day

$= \frac{600 \times 233}{156} = 896.$

$$\frac{\text{Cost of direct labor per day}}{\text{Number of cubic yards per day}} = \frac{\$21.50}{896} = 2.40 \text{ cents per cubic yard.}$$

Process Analysis—Earth	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loosening or breaking	12		7.7	0.185	0.185
Charge to loading					
1. Actual loading . . .	76	30	49.1	1.178	1.824
2. Delays					
a Moving up . . .	39	00	25.0	0.600	
b Repairs.	3	00	1.9	0.046	
Charge to transporting and dumping					
1. Waiting for cars . .	15	30	9.9	0.238	0.391
2. Miscellaneous . . .	10	00	6.4	0.153	
	156	00	100.0	. . .	2.400

Analysis of Complete Dipper Swing		Minimum	Average	Maximum	No. of Obs.	No. of Attempts
Digging . . .	Time in seconds	5	11.6	18	23	41
Swinging loaded		4	7.4	17	23	
Swinging empty		3	5.3	9	23	
Falling . . .		4	7.8	15	23	
Time to fill and load one dipperful . . .		16	32.1	59	23	

Time for a complete swing

	Minimum	Average	Maximum	No. of Observations
Seconds	17	24	42	23

Fig. 73. Dump near Columbia, N. J.

TRANSPORTATION

	From	To	Time Minutes	Distance Feet	Rate Feet per Minute	Delay	Causes of Delay
Dinkey No. 5	Shovel No. 875	Water tower No. 2	2½	1150	460	...	
	Water tower No. 2	Switch No. 2	5½	4375	796	...	
	Switch No. 2	Dump	¾	775	1034	...	
	Dump	Switch No. 2	½	775	1550	2¾	Switching
			...	...	...	5	Dumping
	Switch No. 2	Switch No. 1	¾	760	1014	...	
	Switch No. 1	Water tank No. 2	4	3615	904	...	
	Water tank No. 2	Shovel	1	1150	1150	3	Taking water
			...	...	...	43¾	Waiting for train to load
Total time for round trip			15	12,600	840	54½	= 69½
Dinkey No. 7	Shovel No . 795	Water tower No. 2	6½	4125	635	1	To take off brakes at bottom of grade
	Water tower No. 2	Switch No. 1	5	3615	723	...	
	Switch No. 1	Switch No. 2	1¾	760	435	...	
	Switch No. 2	Dump	1¼	775	620	...	
	Front of train	Rear of train	3	775	258	...	
	Dump	Switch No. 2	¾	775	1034	6¾	Dumping 10 cars
	Switch No. 2	Switch No. 1	1	760	760	...	
	Switch No. 1	Water tower No. 2 switch	3½	3615	1032	1¼	Switching
	Water tower No. 2		...	...	...	3¼	Taking water and switching
	At switch		...	...	...	7½	Waiting for No. 8 to pass
	Water tower No. 2 switch	Side track	6	3425	571	...	
	Side track	Shovel No. 795	...	...	...	15	
Total time for round trip			28¾	18,625	648	34¾	= 63½ minutes

TRANSPORTATION—Continued

	From	To	Time Minutes	Distance Feet	Rate Feet per Minute	Delay	Causes of Delay
Dinkey No. 9	Shovel No. 795	Water tower No. 1	1½	700	467	...	
	Water tower No. 1	Bottom of grade	1½	700	467	...	Helper left
	Bottom of grade	Water tower No. 2	3½	2725	778	...	
	Water tower No. 2	Switch No. 2	5½	4375	795	...	
	Switch No. 2	Dump	1¼	775	620	...	
	Dump	Switch No. 1	1½	1535	1023	3	Switching
	Switch No. 1	Water tower No. 2	4	3615	904	4¾	Dumping
	Water tower No. 2	Side track	6	3425	571	2½	Taking water
	Side track	Shovel	5	...	...	1	Waiting for train to pass
							Dinkey ran around cars here
Total time for round trip			29¾	...	...	11¼	= 41.0
Dinkey No. 5	Shovel No. 875	Water tower No. 2	2¼	1150	512	...	
	Water tower No. 2	Switch No. 1	4¾	3615	761	...	
	Switch No. 1	Switch No. 2	¾	760	1013	...	
	Switch No. 2	Dump	1	775	775	...	
	Dump	Water tower No. 2	5¾	5150	896	3¼	Switching
			...	...	...	4¾	Dumping
	Water tower No. 2	Part way to shovel	¾	...	...	2	Waiting for train to load
			...	...	...	2½	Taking water
			...	...	...	¾	Waiting
			...	...	...	6¼	Taking coal
			...	...	...	10	Waiting
		To shovel	1	...	...	10¼	Blasting
Total time for round trip			16¼	...	...	39¾	= 56 minutes

TRANSPORTATION—Continued

	From	To	Time Minutes	Distance Feet	Rate Feet per Minute	Delay	Causes of Delay
Dinkey No. 7	Shovel No 795	Water tower No. 1	1½	700	467	2	Trying to start
	Water tower No. 1	Bottom of grade	1	700	700	½	½ minute taking off brakes, pusher left train
	Bottom of grade	Water tower No. 2	3½	2725	778	...	
	Water tower No. 2	Switch No. 1	4½	3615	804	...	
	Waiting for train ahead to dump		...	...	...	10	
	Switch No. 1	Switch No. 2	1½	760	506	...	
	Switch No. 2	Dump	1¼	775	620	...	
	Dump	Switch No. 2	1½	775	516	2¼	Dumping
			...	...	...	¾	Hooking up cars
	Switch No. 2	Water tower No. 2	3¾	4375	1166	...	
	Water tower No. 2	Water tower No. 1	3½	3425	979	...	
	Water tower No. 1	Side track	½	350	700	...	
	Side track	Shovel	12	...	...	...	Held at switch

Cost to Move Shovel (65-ton) From Siding to Work. Standard Basis

Runner	40 hours @	$0.50	$20.00
Craneman	40 hours @	0.36	14.40
Fireman	40 hours @	0.24	9.60
Watchman	40 hours @	0.15	6.00
Fireman	40 hours @	0.20	8.00
Laborers	745 hours @	0.15	111.75
Team—ties	40 hours @	0.30	12.00
Team—coal	20 hours @	0.30	6.00
Coal and oil		...	4.50
		...	$192.25

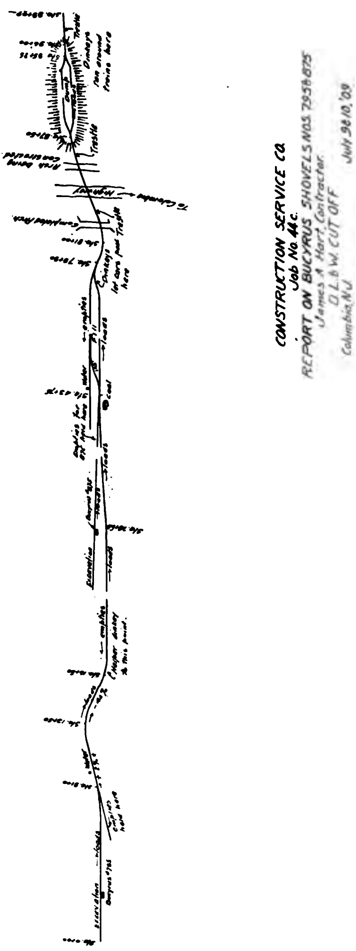

CONSTRUCTION SERVICE CO.
Job No. 44c.
REPORT ON BUCYRUS SHOVELS NOS 7958&875
James A Hart, Contractor.
D.L.&W. CUT OFF
Columbia, N.J. July 9&10,'09

Fig. 74.

Fig. 75. Views of D., L. & W. R. R. Cut-off near Columbia, N. J.

REPORT No. 38 — SHOVEL No. 1137

INSPECTED JULY 1–3 AND 21, 22, 1909

D., L. & W. CUT-OFF

HOPATCONG, N. J.

This shovel was working in section No. 1 of the D., L. & W. cut-off, together with shovel No. 1108, in the report on which will be found a complete description of both. See page 255.

OBSERVATIONS

Weather, clear.

Weight	70-ton
Gauge	Narrow
Capacity of dipper	2½ cubic yards
Kind of teeth	Manganese steel
Maximum height dipper can reach to dump	16½ feet
Length of dipper handle	18′ 6″
Length of boom	28.3′
Height of boom above tracks	25.6′
Height of boom above pivot	20.1′
Maximum distance dipper can reach to dump	26.5′
Swings per minute	2.5
Number of cars loaded	190
Cubic yards excavated	646
Number of times moved forward	6
Average distance moved each time	5′ 10″
Total distance moved forward during day	35′
Time in minutes to load one cubic foot with dipper,	.016 minute
Time shovel is interrupted while spotting one car	.0357 minute
Time shovel is interrupted to change trains	133½ minutes
Time moving forward	83 minutes
Minutes per working day less time for accidental delays	579
Coal used	1.73 tons
Area of section	497 square feet

OBSERVATIONS—*Continued*

Height of face	14½ feet
Number of times blasted bank	3
Average time to move forward once	13.83 minutes
Average time to move forward one foot	2.571 minutes
Average time to load one car	1.446 minutes
Pounds of coal per cubic yard excavated	5.35
Number of cars for one shovel move	31.7
Maximum distance moved forward in one move	6′ 5″
Average time for one swing	24.3 seconds
Average time between beginning of one shovel move and beginning of next	101.3

TRANSPORTATION

Capacity of cars, water measure . . . . . 4.17 cubic yards
Capacity of cars, place measure, 3.3 cubic yards first day; 3.4 cubic yards second day.
Number of cars in train 7
Height of cars above their track . . . . 6′
Length of runaround . . . . 7200′
Weight of dinkeys 18-ton
Style of car . . . . Side dump on one side only
Height of top of cars above shovel track . . . . . . 13½′
Gauge of dinkey track . . . . Narrow
Number of trains 2
Time for round trip . . . . Average, 29.8; maximum, 69½; minimum, 16 minutes; 22 observations
Maximum grade . . . . About 3 per cent against empties
Full trains in grades.
Rate of transportation (feet per minute): Average, 242; maximum. 450; minimum, 104; observations 22.
Distance from inside shovel track to inside track . . . 21.6′

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	7:01	12:30
Stopped work	12:00	5:24

Total time worked 299 minutes + 294 minutes = 9 hours 53 minutes.

	Minutes	Seconds	Per Cent
Actual working	274	45	46.3
Spotting cars	6	45	1.2
Waiting for cars	133	30	22.5
Moving shovel	83	00	14.0
Idle			
Repairing steampipe, dipper and chain	25	30	4.3
Blasting	31	30	5.3
Boulder in bucket	7	30	1.3
Miscellaneous delays			
Moving boulders	9	00	1.5
Clearing way	21	30	3.6
Total time under observation	593	00	100.0

Direct Labor Distribution Per Day	Standard Basis					
	Breaking	Loading	Transporting	Dumping	Incidentals	Total
Runner	...	$5.00	...	...	...	...
Craneman	...	3.60	...	...	...	...
Fireman	...	2.40	...	...	...	...
6 pitmen	...	9.00	...	...	...	...
1 coalman	...	1.50	...	...	...	...
2 locomotive engineers	...	...	5.20	...	...	...
2 brakemen	...	...	3.00	...	...	...
½ section foreman	...	...	...	...	2.00	...
15 laborers	22.50	...	...	...	...	...
5 drillers	12.50	...	...	...	...	...
5 drillers' helpers	8.75	...	...	..	...	...
4 dumpers	...	...	...	6.00	...	...
1 powderman	2.00	...	...	...	...	...
1 powderman's helper	1.50	...	...	...	...	...
1 boiler fireman	2.00	...	...	...	...	...
1 blacksmith	...	...	...	...	3.00	...

Direct Labor Distribution Per Day (Continued)	Standard Basis					
	Breaking	Loading	Transporting	Dumping	Incidentals	Total
1 blacksmith's helper . . .	...	...	...	..	1.50	...
1 boiler fireman	1.50	...	...	...	...	...
1 well driller .	2.50	...	...	...	...	...
Half watchman	...	...	...	...	0.75	...
1 assistant watchman .	...	...	...	...	1.50	...
1 pumptender .	...	...	...	...	1.50	...
7 trackmen . .	...	...	10.50	...	...	...
2 waterboys .	...	...	...	...	2 00	...
Superintendent.	...	...	...	...	6.00	...
Total cost of direct labor per day .	$53.25	$21.50	$18.70	$6.00	$18.25	$117.70
Cost per day per cubic yards (cts)	8.24	3.33	2.89	0.93	2.83	18.22
Per cent . . .	45.2	18.3	15.9	5.1	15.5	100.00

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to waiting for blasters	40	30	6.8	0.227	0.227
Charge to loading					
1. Actual loading . . .	274	45	46.3	1.541	2.193
2. Delays					
a Moving up . . .	83		14.0	0.466	
b Repairs	25	.30	4.3	0.143	
c Miscellaneous . .	7	30	1.3	0.043	
Charge to transporting and dumping					
1. Waiting for cars . .	140	15	23.7	0.790	0.910
2. Miscellaneous . . .	21	30	3.6	0.120	
	593		100.0		3.330

CALCULATED AND OBSERVED DATA—SECOND DAY

Swings per minute	2.43
Number of cars loaded	157
Cubic yards excavated	551
Number of times moved forward	6
Average distance moved forward each time	5′ 8″
Total distance moved forward during day	34′ 0″
Time in minutes to load one cubic foot with dipper	.017
Time shovel is interrupted to change trains	30½ minutes
Time moving forward	71¾ minutes
Minutes per working day less time for accidental delays	453
Area of section	412 square feet
Height of face	11′
Number of times blasted bank	3
Average time to move forward once	11.96 minutes
Average time to move forward one foot	2.11 minutes
Average time to load one car	1.893 minutes
Number of cars for one shovel move	26.2
Maximum distance moved forward in one move	6′ 0″
Average time for one swing	24.7 seconds
Average time between beginning of one shovel move to beginning of next	98.7 seconds

TIME STUDY—SECOND DAY

	Forenoon	Afternoon
Started work	7:00	12:30
Stopped work	12:00	5:30

	Min.		Min.	
Total time worked	300	+	300	= 10 hours.

	Minutes	Seconds	Per Cent
Actual working	307	15	51.2
Waiting for cars	30	30	5.1
Moving shovel	71	45	12.0
Idle			
Repairs	1	00	0.2
Blasting	29	00	4.8
Replacing dipper	147	00	24.5
Miscellaneous delays			
Chaining boulder	8	00	1.3
Moving boulders	5	30	0.9
Total time under observation	600	00	100.0

COST OF DIRECT LABOR (LOADING) PER DAY STANDARD BASIS

The direct labor distribution during the second day's observation was the same as upon the first, with the exception that the seven trackmen were not employed, and that one extra well driller and two assistant watchmen were engaged, affecting the results as follows:

	Breaking	Loading	Transporting	Dumping	Incidentals	Total
Total cost of direct labor per day .	$55.75	$21.50	$8.20	$6.00	$19.75	$111.20
Cost per day, per cubic yard, cents	10.12	3.90	1.49	1.09	3.58	20.18
Per cent	50.2	19.3	7.4	5.4	17.7	100.0

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to waiting for blasters	42	30	7.1	0.277	0.277
Charge to loading					
1. Actual loading . . .	307	15	51.2	1.996	3.424
2. Delays					
a Moving up . . .	71	45	12.0	0.468	
b Repairs	148		24.6	0.960	
Charge to transporting and dumping					
1. Waiting for cars . .	30	30	5.1	0.199	0.199
	600		100.0		3.900

Analysis of Complete Dipper Swing		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging . . .	Time in seconds	5	16.37	53	34	57
Swinging loaded	Time in seconds	5	7.53	15	34	
Swinging empty	Time in seconds	3	6.06	14	32	
Falling . . .	Time in seconds	3	7.35	20	31	
Time to fill and load one dipperful		16	37.31	102		

Time for complete swing

	Minimum	Average	Maximum	No. of Obs.	No. of Attempts
Seconds	15.5	24.3	40	50	50

Number of swings per minute

	Minimum	Average	Maximum	No. of Obs.	No. of Attempts
	1.5	2.5	3.9	50	50

Per cent of full dipper to number of attempts to fill the dipper= $\frac{34}{57} = 59.6$ per cent.

Labor Cost Replacing Dipper Handle Time Required

		Per Day	2½ Hours
Runner	@	$5.00	$1.25
Craneman	@	3.60	0.90
Fireman	@	2.40	0.60
6 pitmen	@	1.50	2.25
Foreman	@	4.00	1.00
Rigger	@	3.00	0.75
2 locomotive engineers	@	2.60	1.30
2 brakemen	@	1.50	0.75
4 men on dump	@	1.50	1.50
Total			$10.30

Fig. 76

Fig. 77. Views on the D., L. & W. R. R. Cut-off, Hopatcong, N. J.

REPORT No. 42 — SHOVEL No. 350

INSPECTED JULY 2 AND 20, 1909

NEAR NETCONG, N. J.

LOCATION Section No. 2 (Waltz & Reece, contractors), on the D., L. & W. cut-off, is located about three miles north of the village of Netcong, on the main line of the D., L. & W. Railroad. The section is about two and one-half miles long and is about equally divided between cut and fill, one of the deepest (110 feet, maximum) side hill cuts on the line being located here.

MATERIAL This work is entirely in porphyry and is about 2000 feet long and 150 feet wide at the foot of slope at present. About 30 feet are still to be taken out before reaching grade. There are about 770,000 cubic yards of excavation in this cut, and which is expected to make a fill of 1,270,000 cubic yards, implying an expansion of about 65 per cent. The material, when properly blasted, breaks up into small chunks that make very easy digging, but if, as on one of the days of our observation, the holes are not properly spaced, or heavily enough charged, and the rock in consequence not well broken, the digging is hard and very wearing on the shovel. Unusually hard digging was experienced during our night observations on July 22 and the following day.

DRILLING Since the holes drilled are 30 feet deep, and, in order to break up the rock, must be very large in diameter, it has been found more economical, and more convenient in handling the long drill steel, to use well drills rather than the largest steam drills. The contractors also claim that the rock is so hard and fissured that it would make poor drilling for

steam machines. On the first day of our observations two of these well drills were in operation and on the remaining days four.

GENERAL ARRANGEMENT The illustrations and the sketch on page 344 show the track arrangement. The one leading to the Bucyrus shovel is visible at the extreme right. This switches back along the face of the cut to the Bucyrus shovel and past that to the Marion indicated by the white streak of steam in the background. From this point the cars are switched past the second Marion, shown at the left, and upon the side hill tracks shown at the extreme left. Figure 80 shows these tracks as they extend down the hill to the fill, the left hand one being for loads and the right hand one for empties.

DESCRIPTION OF SHOVEL Bucyrus shovel No. 350 weighs 65 tons, has standard gauge railway car trucks, and an all-steel boom and dipper handle. It is about ten years old and has been used by

Kilpatrick Brothers & Collins, at Sherman Hill, N. Y.
Mike Elmore, Western Maryland Railway.
Waltz & Reece, D., L. & W. cut-off.

Figure 81 shows the shovel as it appeared at the D., L. & W. cut-off on July 23. It will be noticed that the dipper chain passes over two wheels side by side on the same axle at the point of the boom rather than over two wheels, one behind the other. The boom is provided with an auxiliary engine for holding the dipper to the face. The jacks fold against the A frame. Water is supplied to the tank through a hose attached to a pipe which runs to a tank on the hill and is pumped into the tank from a distant brook. Coal is brought

in by teams and shoveled aboard the dump cars, which are then hauled to the shovels and dumped as needed, a laborer carrying it in small boxes from this pile to the shovel. This shovel has seen much usage, but is now doing good work and is in some very hard digging.

TIME STUDY Three complete runs for this shovel have been obtained: One on July 2, 1909; one during the night of July 20–21, and one on July 21.

Date	Minutes Loading	Time Waiting for Cars Per Cent of Total	Time Blasting Per Cent of Total	Number Cars Loaded
July 2	241	17.5	0.11	177
July 20 (night)	241.4	18.8	24.9	88
July 21	228.2	9.9	26.2	123

From the above it appears that the hardest digging was on the 20th and 21st, and that the darkness on the 20th materially affected the output. This is also shown by the time taken to fill the dipper before dumping. On the 2d the ratio of attempts to fill the dipper to complete dipperfuls was 133 trials to 45 complete dipperfuls, while on the 20th (night) it was 232 to 22, and on the 21st 210 to 21 complete dipperfuls. The time for a complete swing did not vary much in the three cases, and the number of swings per minute averaged about 2½ to 3, the machine being designed for about three. This time for a complete swing is taken from the moment the dipper point touches bottom until it comes back to the same position, and includes only those cases where it works freely and without delay. This is given in detail later. The time to fill and load one dipperful, as given in these tables, includes all

delays. The observations were taken at random, and every attempt to fill the dipper was recorded and included in the time to get a dipperful before loading. This also gives another indication of the nature of the material, for on July 2 the average time to load a dipper was 26.1 seconds, while on the 20th (night) it was 34.4 seconds, and on the 21st 35.4 seconds.

We happened to come upon the shovel on the 20th and 21st, when it had struck a hard spot that was poorly blasted, while on the 2d the material was well blasted, broken into small pieces, and was not much more difficult to dig than ordinary gravel. The comparison, as shown above, is very marked and interesting. Light was supplied for the night work by large acetylene lamps with reflectors.

It will be noted that the time for spotting cars on July 2 was very large. This was due mainly to the cars being so well filled that the material fell over the sides and thus blocked the track until it was removed. On July 20 and 21 this amounted to only four minutes, as against 21 minutes on July 2.

By "clearing track" is meant the operation of *pulling* in the rock next to the dinkey tracks as it accumulates near them in the course of the digging.

OBSERVATIONS—GENERAL

Weight	65 tons
Gauge	Standard
Capacity of dipper	2½ cubic yards
Kind of teeth on dipper	Manganese steel
Height blocked up	None (all three observations)
Weather, clear (all three observations)	
Maximum height dipper can reach to dump	12.5′
Length of dipper handle	16′ 8″
Length of boom	25′
Height of point of boom above tracks	21′
Maximum distance dipper can reach to dump	26
Height of cars above their track	5½′
Length of haul (approximate)	7000′
Length of runaround	15,745′ = 2.98 miles

OBSERVATIONS—GENERAL—*Continued*

Weight of dinkeys . . . . 12 tons, 16 tons, 18 tons
Style of car: Side dump on both sides; four new ones with steel protection plates for wheels. (See Fig. 83.)
Height of cars above shovel track . . . . 6′
Gauge of dinkey tracks . . . . Narrow
Number of trains 5
Maximum grades for loads . . . . 2 per cent to 2½ per cent
Maximum grades for empties . . . 2 per cent to 2½ per cent
Complete trains for grades.
Average time to dump cars . . . . 3 minutes
Distance from inside dinkey track to inside shovel track . 16′

OBSERVATIONS—FIRST DAY

Swings per minute 2.95
Number of cars loaded 177
Number of cubic yards excavated 630
Number of times moved forward 10
Average distance moved each time . . . . 5′ 4¾″
Total distance moved forward during day . . . . . 54′ 0″
Time in minutes to load one cubic foot with dipper 020
Time shovel is interrupted while spotting one car . 0.119 minute
Minutes per working day, less time for accidental delays 570½
Shovel expense in cents, one day, not including superintendent and overhead or preparatory charges, 3358
Areas of section . . . . 350 square feet
Height of face . . . . 25′
Number of times blasted bank 2
Average time to move forward once . . . . 12 minutes
Average time to move forward one foot . . . . 2.22 minutes
Average time to load one car . . . . 1.362 minutes
Total cost to excavate, transport and spread one cubic yard, 38.17 cents
Number of cars for one shovel move 17.7
Average time for one swing 20.3
Average time between beginning of one shovel move to beginning of next, 56.4.

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	7:00	12:11
Stopped work	11:30	5:11½

Total time worked 270 Min. + 300½ Min. = 570½ Min. = 9 hours 30 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	241	00	42.3
Spotting cars	21	00	3.7
Waiting for cars	100	00	17.5
Moving shovel	120	00	21.0
Idle	(65	30)	(11.5)
Laying ties to move up number of cars	20	30	3.6
Placing dinkey on track	15	30	2.7
Repairing dipper chain	23	00	4.0
Blasting	6	30	1.2
Miscellaneous delays	(23	00)	(4.0)
Breaking down bank	18	30	3.2
Clearing tracks	4	30	0.8
Total time under observation	570	30	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
7 pitmen	10.50
	$21.50

Cubic yards loaded on first day of observation 630

Cost of direct labor per day per cubic yard $= \dfrac{\$21.50}{630} = 3.41$ cents per cubic yard.

Process Analysis	Time		Per Cent	Cost in Cents per Cubic Yard	Total Cost
	Min.	Sec.			
Charge to waiting for blasters	25	00	4.4	0.150	0.150
Charge to loading					
1. Actual loading	241	00	42.3	1.443	2.418
2. Delays					
a Moving up	120	00	21.0	0.716	
b Repairs	23	00	4.0	0.136	
c Miscellaneous	20	30	3.6	0.123	
Charge to transporting and dumping					
1. Waiting for cars	121	00	21.2	0.723	0.842
2. Miscellaneous	20	00	3.5	0.119	
	570	30	100.0	. . .	3.410

Analysis of complete Dipper Swing		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging . . .	Time in seconds	4	10.0	29	45	60
Swinging loaded		3½	5.95	14	46	..
Swinging empty		3	5.10	8	44	..
Falling		1	5.07	10	41	..
Time to fill and load one dipperful		11½	26.12	61	..	..

Time for a complete swing

	Minimum	Average	Maximum	No. of Obs.
Seconds	11	20.3	39.5	71

Swings per minute

	Maximum	Average	Minimum	No. of Obs.
	5.45	2.95	1.52	71

OBSERVATIONS—SECOND DAY

Swings per minute 2.67
Number of cars loaded 88
Cubic yards excavated 264
Number of times moved forward 3
Average distance moved each time . . . . 3′ 8″
Total distance moved forward during day . . . . . 11′ 0″
Time in minutes to load one cubic foot with dipper . . .0253
Time shovel is interrupted while spotting one car . .05 minute
Minutes per working day less time for accidental delays . 593
Shovel expenses in cents, one day, not including superintendent and overhead or preparatory charges 3508
Coal used . . . . 2.2 tons
Area of section . . . . 325 square feet
Height of face . . . . 27′
Number of times blasted bank 11
Average time to move forward once . . . . . 19.75 minutes
Average time to move forward one foot . . . 5.386 minutes

OBSERVATIONS—SECOND DAY—*Continued*

Average time to load one car . . . . 2.743 minutes
Pounds coal per cubic yard excavated 16.6
Total cost to excavate, transport and spread one cubic yard, 33.5 cents.
Number of cars for one shovel move 29.3
Maximum distance moved forward in one move . . . 5′ 6″
Average time for one swing . . . . 22.9 seconds
Average time between beginning of one shovel move and beginning of next . . . . 186½ seconds

TIME STUDY—SECOND DAY

Worked at night

	Afternoon	Forenoon
Started work	6:25	11:57 P. M.
Stopped work	11:27½	5:00 A. M.

Total time worked 302½ Min. + 303 Min. = 605½ Min. = 10 hours 5 minutes 30 seconds

	Minutes	Seconds	Per Cent
Actual working	241	30	39.9
Spotting cars	4	00	0.7
Waiting for cars	114	00	18.8
Moving shovel	59	30	9.8
Idle	(160	00)	(26.4)
Putting chain on block . .	3	00	0.5
Blasting	150	30	24.8
Removing boulder from teeth	6	30	1.1
Miscellaneous delays . . .	(26	30)	(4.4)
Putting car on track . . .	3	00	0.5
Breaking bank	12	00	2.0
Clearing track	11	30	1.9
Total time under observation .	605	30	100.0

Cost of direct labor (loading) per day, standard basis . $21.50
Cubic yards loaded during observation (night) 264

Cost of direct labor per day, per cubic yard $= \frac{\$21.50}{264} =$ 8.14 cents per cubic yard.

Process Analysis—Second Day	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to waiting for blasters	162	30	26.8	2.180	2.180
Charge to loading					
1. Actual loading . .	241	30	39.9	3.248	4.177
2. Delays					
a Moving up . . .	59	..	9.8	0.798	
b Repairs	3	..	0.5	0.041	
c Miscellaneous . .	6	30	1.1	0.090	
Charge to transporting and dumping					
1. Waiting for cars . .	118	30	19.5	1.587	1.783
2. Repairs to cars . .	11	30	1.9	0.155	
3. Miscellaneous . . .	3	..	0.5	0.041	
	605	30	100.0	. .	8.140

Analysis of Complete Dipper Swing		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging . . .	Time in seconds	5	15.20	40	22 (1)	51
Swinging loaded		3	6.02	11	22	..
Swinging empty		3	5.91	11	17	..
Falling . . .		2½	7.30	2½	20	..
Time to fill and load one dipperful		13½	34.43	64½	..	..

Time for a complete swing

	Minimum	Average	Maximum	No. of Observations
Seconds	13	22.9	39	22

Swings per minute

Maximum	Average	Minimum	No. of Observations
4.6	2.7	1.54	22

(1) Gives the average time for a complete swing with no allowance for hard digging.

OBSERVATIONS—THIRD DAY

Swings per minute	2.67
Number of cars loaded	123
Cubic yards excavated	369
Number of times moved forward	2
Average distance moved each time	3′ 11″
Total distance moved during day	7′ 10″
Time in minutes to load one cubic foot with dipper,	.028 minute
Time shovel is interrupted while spotting one car	.027 minute
Minutes per working day less time for accidental delays	556
Shovel expenses in cents, one day, not including superintendent and overhead or preparatory charges	3358
Coal used	2 tons
Area of section	325 square feet
Height of face	27′
Number of times blasted bank	10
Average time to move forward once	12 minutes
Average time to move forward one foot	3.064 minutes
Average time to move one car	1.95 minutes
Pounds coal per cubic yard, excavated	11 pounds
Total cost to excavate, transport and spread one cubic yard	58.26c.
Number of cars for one shovel move	61.5
Maximum distance moved forward in one move	5′ 10″
Average time for one swing	27.8 seconds
Average time between beginning of one shovel move and beginning of next	224 minutes

TIME STUDY—THIRD DAY

	Forenoon	Afternoon
Started work	6:28	12:11½
Stopped work	11:26½	5:08½

Total time worked Min. 298½ + Min. 297 = 595½ minutes = 9 hours 55 minutes 30 seconds.

	Minutes	Seconds	Per Cent
Actual working	228	12	38.3
Spotting cars	3	48	0.6
Waiting for cars	59	00	9.9
Moving shovel	24	00	4.0
Idle	(171	00)	(28.8)
Oiling up	5	00	0.8
Boulder in dipper	6	00	1.0
Blasting	158	00	26.6
Jacking	2	00	0.4
Miscellaneous delays . . .	(109	30)	(18.4)
Clearing track	16	30	2.8
Breaking bank	18	30	3.1
Repairing boom drain and dipper	39	30	6.6
Taking boulder off track .	35	00	5.9
Total time under observation .	595	30	100.0

Cost of direct labor (loading) per day. Standard basis . $21.50
Cubic yards loaded during third observation 369

$$\text{Cost of direct labor per day per cubic yard} = \frac{\$21.50}{369} = 5.82 \text{ cents}$$

per cubic yard.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost
	Min.	Sec.			
Charge to loosening or breaking	176	30	29.6	1.722	1.722
Charge to loading					
1. Actual loading . .	228	2	38.3	2.230	2.975
2. Delays					
a Moving up . . .	24	..	4.0	0.233	
b Repairs	39	30	6.6	0.384	
c Miscellaneous . .	13	..	2.2	0.128	
Charge to transporting and dumping					
1. Waiting for cars . .	62	8	10.6	0.617	1.123
2. Miscellaneous . .	51	30	8.7	0.506	
	595	30	100.0	. . .	5.820

Analysis of Complete Dipper Swing		Minimum	Average	Maximum	No. of Observations	No. of Attempts to Fill Dipper
Digging	Time in seconds	6	14.4	32	21	44
Swinging loaded		3	8.0	15	21	..
Swinging empty		5½	9.0	20	21	..
Falling		3	4.0	6	21	..
Time to load and empty one dipperful		17½	35.4	73	21	..

Time for one complete swing

	Minimum	Average	Maximum	No. of Observations
Seconds	22.5	27.8	39	19

Number of swings per minute

Minimum	Average	Maximum	No of Observations
1.54	2.12	2.66	19

	From	To	Time Minutes	Distance Feet	Rate Feet Per Minute	Delay Minutes	Time for Trip Minutes	Causes of Delays
Dinkey No. 1	Shovel No. 350	Third switch	4	1650	412.5	. . .		
	Third switch	Blacksmith shop	3½	2000	571.4	. . .	8.48 to 10.13½ A.M.	
	Blacksmith shop	Dump	7½	4700	626.6	5		Dumping
	Dump	Water tower	1	300	300.0	1¼		Taking water
	Water Tower	Blacksmith shop	5½	4400	800.0	. . .		
	Blacksmith shop	Switch	1½	2000	1333.3	52¼		Getting cars repaired while shovel is being repaired
	Switch	Shovel	4	950	237.5	. . .		
Total			27	16,000	Av. 592.6	58½	58½	
Dinkey No. 7	Shovel No. 350	Marion shovel	2	800	400.0	5	. . .	Completing load
	Marion shovel	Switch	2	850	425.0	1	. . .	Switching
	Switch	Blacksmith shop	3½	2000	571.4	. . .	2.59 P.M. 3.59 P.M.	
	Blacksmith shop	Dump	8½	4700	552.9	. . .	. . .	
	Dump	Blacksmith shop	6	4700	783.3	3½	. . .	Dumping
	Blacksmith shop	Switch	1½	2000	1333.3	4½	. . .	Car off track
	Switch	Shovel	7	950	135.7	3½	. . .	Going for coal
					. . .	12	. . .	Coal car off track
								Three empty cars now at shovels, one standing idle
Total			30½	16,000	Av. 600.2	29½	. . .	
Dinkey No. 5	Shovel No. 350	Marion shovel	½	800	1600.0	6	. . .	Train ahead loading Loading one car
	Marion shovel	Switch	4	850	212.5	1	4.14 P.M. 5.16 P.M.	
	Switch	Blacksmith shop	3½	2000	571.4	. . .	. . .	
	Blacksmith shop	Dump	10	4700	470.0	11½	. . .	Delay at switch to single track because of train ahead at dump
	Dump	Water tank	2½	300	120.0	3½ 11	. . . . . .	Dumping stone caught in door of car
	Water tank	Switch	5	4400	880.0	1	. . .	Taking water
	Switch	Shovel	2½	950	380.0	. . .	. . .	
Total			28	. . .	Av. 604.8	34	62	

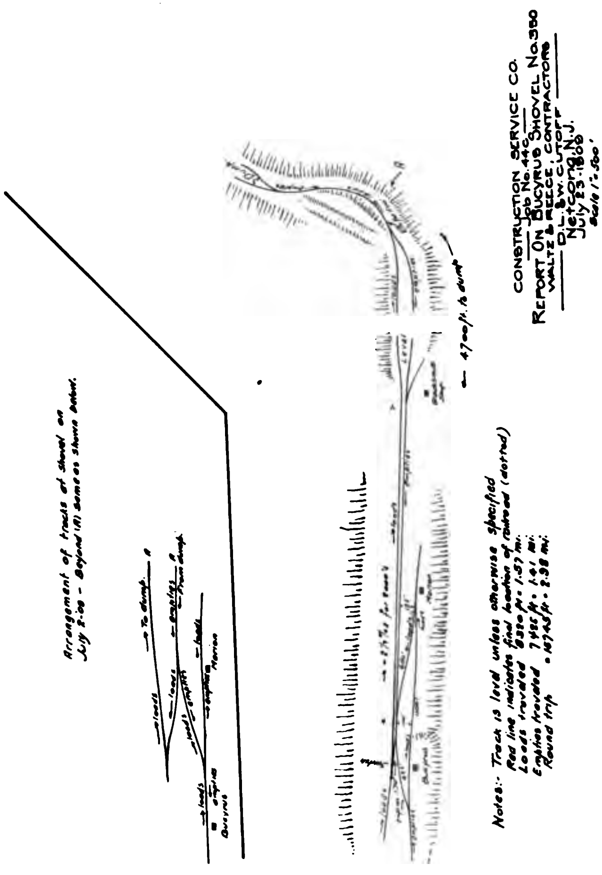

Arrangement of tracks at shovel on
July 2-09 - Beyond (R) same as shown below.
CONSTRUCTION SERVICE CO.
Job No. 440.
REPORT ON BUCYRUS SHOVEL No. 350
WALTZ & REECE, CONTRACTORS
D.L.&W. CUTOFF
Netcong, N.J.
July 23. 1909
Scale 1"=500'
4700 ft. to dump
Notes:- Track is level unless otherwise specified
Red line indicates final location of railroad (dotted)
Loads traveled 8310 ft = 1.57 mi.
Empties traveled 7485 ft = 1.41 mi.
Round trip = 15795 ft = 2.98 mi.

Fig. 78

Fig. 79. Scenes on D., L. & W. Cut-off Near Netcong, N. J.

Fig. 80

Fig. 81. 65-ton Bucyrus Shovel on D., L. & W. Cut-off Near Netcong, N. J.

Fig. 82

Fig. 83. Scenes on Sec. 2, D., L. & W. Cut-off

REPORT No. 43 — SHOVEL No. 1106

INSPECTED JULY 23, 24, 1909

SOO ST. MARIE, MICH.

GENERAL CONDITIONS This shovel is engaged in the improvement of the United States Ship Canal above the locks at Soo St. Marie, Mich., and is operated by the Great Lakes Dredge and Dock Company, which has the contract for widening the present canal over an area averaging 125 feet in width and 3700 feet in length to a depth which would allow 24.6 feet of water.

MATERIAL The material is almost entirely of Potts-dam sandstone with occasional stratifications of hard white rock. Due to the material and the character of the blasting, the work for the shovel is extremely difficult, as is shown in some of the figures. The rock is broken into large irregular pieces, many of which must be pushed aside by the shovel. The shovel was just cutting out on the first day of investigation. It moved back 800 feet during the night and cut in next morning.

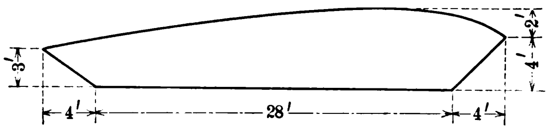
MOVING BACK AND THROWING TRACK The throwing of the loading track was very difficult because of the roughness of the material which was left in the shovel pit and because of the large number of boulders which the shovel could not handle. Much delay was caused on account of having to break up boulders to permit of lifting full sections of track over them, and considerable time was lost for both track gang and shovel crew by blasting. The blast itself took no longer than usual, but because of the uneven

character of the material the charge could not always be properly regulated, with the result that very often considerable damage was done to the track and to the shovel by flying material. The track foreman said that with a crew of twenty men it would take two hours' continuous work to throw 800 feet of track. Most of the track had been thrown before the shovel moved back. When the shovel did move back over this part the rails were placed over the track which had been thrown. Moving back was also interrupted, due to blasts. The foreman said that with an average force of twenty-two men the shovel could be moved back the 800 feet in four hours' continuous work.

After the shovel had moved back and cut in, it encountered many boulders which were too large to be loaded into the dump cars. They had to be clawed out and tossed to one side to be broken up later. Other boulders somewhat smaller in size, but still too large to be handled by the dipper, were raised and lowered into the cars by chains. Altogether it was very difficult work for the shovel, which accounts for the poor showing that it made.

Transportation was also hard work. At the time of the first day's observation the shovel was worked beside the loading track, which was on a 5% grade. This extended for some distance on both sides of the shovel and gave the trains no opportunity to start. After leaving a pit considerable switching was necessary before the trains could get upon the dump track.

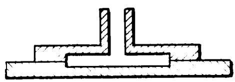
The job was well supplied with water, and the supply for the shovel was obtained through a hose about 300 feet long, extending over the bank from a water main. Coal was brought in by the regular dump train and dumped behind the shovel, and then carried on board in boxes by the pitmen.



Cross section of bank, sketched a short time before shovel had to cut out and run back to enter new cut.

OBSERVATIONS

Weather, bright and clear; brisk north winds.
Distance of move . . . . 6'
Type of shovel 70-ton
Kind of teeth . . . . Rock
Height of lift . . . . 10'
Size of ties under shovel: Regular size of tie, 6" x 8", but to each 6-foot length of rail there was one 8" x 10" tie. On this tie plates were fastened, at the proper distance from each end, each with two angles attached.



Upon moving up each time the 6-foot rail section could be readily slipped into the groove, as shown in sketch, and pins slipped into holes to secure it.
Size of bucket . . . . 2¼ yards
Age of shovel . . . . 1 year
Duration of job . . . . 2½ months
Shift . . . . Eight hours long; two shifts per day
Water is pumped through line of hose about 300 feet long. Coal is drawn to shovel by dinkey and then dumped. Carried on to shovel in boxes by pitmen. Repairs are made on Sunday by regular crew.
Coal used per day of 16 hours . . . . 3 tons
Oil used per day of 16 hours: Cylinder, 2 gallons; black, 3 gallons
Water used . . . . 4500 gallons per 16 hours
Boiler is cleaned every other Sunday
Contract price: 55 cents per yard for earth and soft material; $1.30 per yard for rock.
Contract includes excavation channeling, building and filling cribs, concrete.
Kind of track, etc. . . . . . . Rail, 30-pound; 3-foot gauge
Kind and size of cars used . . . . . K and G 1905; 4-yard

OBSERVATIONS—*Continued*

Train is braked by steam brake on engine. Hand brake on cars
Hand signals are used by man on shovel
Kind and size of dinkey . . . H. T Porter Company, 14-ton
Haul is about one-half mile long
Number of trains, three { No. 4, 10 cars; No. 5, 8 cars; No. 6, 10 cars } 7/24/09; 8-car trains on 7/23/09
Age of cars and dinkey: Dump cars, 1905; dinkeys, 1909 and 1907.

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	8:48:00	00:00:00
Stopped work	11:54:45	00:00:00

Total time worked 186 min. 45 sec. = 3 hours 6 minutes 45 seconds.

	Minutes	Seconds	Per Cent
Actual working	65	24	35.1
Waiting for cars	74	14	39.8
Moving shovel	47	7	25.1
Total time under observation .	186	45	100.0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
	$20.00

Cars loaded during observation . . . 80 at 4 yards = 320 yards
Cubic yards loaded during observation . . 80 x 4 x 0 6* = 192
Based on observed performance, cubic yards loaded per day of

$$8 \text{ hours} = \frac{192 \times 480}{186.75} = 495.$$

Cost of direct labor per day in cubic yards $= \frac{\$20.00}{495} =$ 4.04 cents per cubic yard.

Process Analysis	Time Minutes	Time Seconds	Per Cent	Charge Cents	Total
Charge to loading					
1. Actual loading .	65	24	35.1	1.419	2.433
2. Delays					
a Moving up . .	47	7	25.1	1.014	
Charge to transporting and dumping					
1. Waiting for cars .	74	14	39.8	1.607	1.607
			100.0		4.040

$* 0.6 = \text{ratio of } \frac{\text{p. m.}}{\text{w. m.}}$

TIME STUDY DEDUCTIONS—FIRST DAY

	No. of Observations	Minimum Min.	Minimum Sec.	Average Min.	Average Sec.	Maximum Min.	Maximum Sec.
Time idle, shovel moving up	7	6	32	7	51	8	45
Time between moves, shovel working . .	5	8	10	11	17	14	50
Time between trains .	8	7	16	9	17	13	15
Time per train loading	10	4	00	6	32	8	43
Time per dipper . .	7	.	17	..	22	..	26
Number of dippers per move	5	27		32		40	
Number of dippers per train	10	16		18.2		23	
Number of dippers per car	80	..		2.3		..	

Number of trains loaded 10
Number of cars loaded 80
Cars per train 8

TIME STUDY—SECOND DAY

	Forenoon	Afternoon
Started work	8:39:55	
Stopped work		4:30:00

	Min.	Sec.	
Total time worked	470	5	= 7 hours 50 minutes 5 seconds

	Minutes	Seconds	Per Cent
Actual working	246	35	52.5
Waiting for cars	60	30	12.9
Moving shovel	108	15	23.0
Miscellaneous delays . . .	(54	45)	(11.6)
Clearing boulders	20	00	4.2
Coaling and changing shifts	27	15	5.8
Small repairs	7	30	1.6
Total time under observation .	470	5	100.0

Cost of Direct Labor (Loading) per Day

Number of cars loaded during observation . . 107 @ 4 yard

Cubic yards loaded during observation . 107 x 4 x 0.6* = 257

Based on observed performance cubic yards loaded per day of 8 hours $= \dfrac{257 \times 480 \text{ minutes } 0 \text{ seconds}}{470 \text{ minutes } 5 \text{ seconds}} = 262$

Cost of direct labor per day, per cubic yard $= \dfrac{\$20.00}{262} = 7.64$ cents per yard.

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost per Yard in Cents	Total Cost
Charge to loading					
1. Actual loading . .	246	35	52.5	4.011	6.654
2. Delays					
a Moving up . . .	108	15	23.0	1.757	
b Miscellaneous . .	54	45	11.6	0.886	
Charge to transporting and dumping					
1. Waiting for cars . .	60	30	12.9	0.986	0.986
	470	5	100.0	. . .	7.640

* $0.6 =$ ratio of $\dfrac{\text{P. M.}}{\text{W.M.}}$

TIME STUDY DEDUCTIONS—SECOND DAY

	No. of Obser-vations	Cutting In. Many Boulders.					
		Minimum		Average		Maximum	
		Min.	Sec.	Min.	Sec.	Min.	Sec.
Time idle, shovel moving up	10	7	55	10	49	15	00
Time between moves, shovel working . .	11	4	25	22	25	40	50
Time between trains .	7	3	30	8	38	12	30
Time per train loading	11	15	20	21	41	28	00
Time per dipper . .	11	..	33.9	.	50.6	..	62.7
Number of dippers per move	11	5		28		43	
Number of dippers per train	11	22		$27\frac{2}{11}$		30	
Number of dippers per car	107	..		2.86		..	

Number of trains loaded 12

Number of cars loaded 107

Cars per train . . . . 8 trains of 10 cars each; 3 trains of 8 cars each; 1 train of 3 cars

ACTUAL RATIOS

$$\frac{\text{Water consumption, pounds}}{\text{Coal consumption, pounds}} = \frac{37{,}500}{6{,}000} = 6.25$$

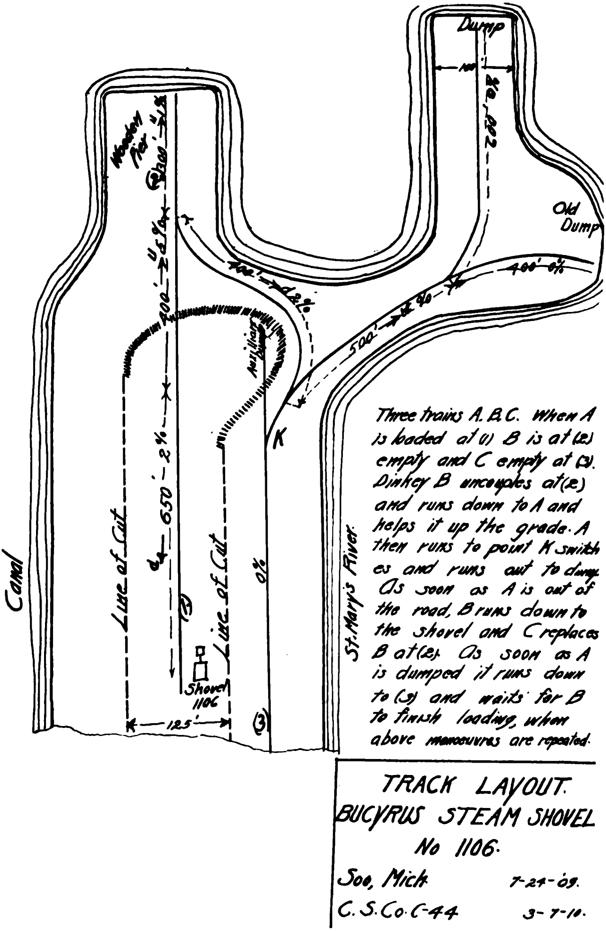

Dump
100'
Old Dump
400' 0%
Wooden Pier
K
Canal
Line of Cut
650'-2%
Line of Cut
0%
St. Mary's River
Shovel 1106
125'
(2)
(3)
Three trains A. B. C. When A is loaded at (1) B is at (2) empty and C empty at (3). Dinkey B uncouples at (2) and runs down to A and helps it up the grade. A then runs to point K switches and runs out to dump. As soon as A is out of the road, B runs down to the shovel and C replaces B at (2). As soon as A is dumped it runs down to (3) and waits for B to finish loading, when above manoeuvres are repeated.
TRACK LAYOUT.
BUCYRUS STEAM SHOVEL
No 1106.
Soo, Mich 7-24-09.
C.S.Co. C-44 3-7-10.

Fig. 84

Fig. 85. Shovel No. 1106 Near Soo Ste. Marie, Mich.

REPORT No. 45 — SHOVEL No. 875

INSPECTED AUGUST 11 AND 21, 1909

NEAR COLUMBIA, N. J.

Shovel No. 875 was working on Section No. 7 of the D., L. & W. cut-off near Columbia, N. J., together with No. 795, under the report on which will be found a general description relative to both. See page 312.

No. 875 has an all-steel boom and dipper handle. The boom is reinforced with lattice bracing, and does not spread in hard digging.

OBSERVATIONS—GENERAL

Weight . . . . 70 tons
Gauge . . . . Standard
Height of lift . . . . $5\frac{1}{2}'$
Kind of teeth . . . . Manganese steel
Height blocked up . . . . $1'$
Pivot of boom . . . . $5'$ above track of shovel
Length of boom . . . . $28'$
Length of dipper handle . . . . $18.3'$
Distance from inside shovel track to inside track . . . . $21'$
Reach of boom . . . . $15.7'$
Height of point of boom above pivot of boom . . . . . $18'$
Farthest dipper can reach to dump . . . . $29'$
Highest dipper can reach to dump . . . . $16'$
Difference in elevation between shovel and dinkey track, = 0.
Diameter of swing circle . . . . $7\frac{1}{2}'$
Diameter of bank (when broken) . . . . $7\frac{1}{2}'$
Dipper depth = 48″, lip = 60″, teeth = 75″.
Weather, clear.
Capacity of cars . . . . 2 yards when loaded with rock
Number of cars in one train 10
Height of cars above their track . . . . $5\frac{1}{2}'$
Length of haul (approximate) . . . . $6300'$
Length of runaround (approximate) . . . . $12600'$
Weight of dinkeys . . . . 18 tons
Style of car: Side dump on both sides; and also side dump, one side only.
Height of cars above shovel track . . . . $5\frac{1}{2}'$
Gauge of dinkey track . . . . Narrow

OBSERVATIONS—GENERAL—*Continued*

Number of trains 2
Grades. One at shovel about 50′ long, over which the loaded cars could not be hauled. Otherwise none.
Full trains on grades, with extra dinkey to help.
Number of cars loaded 121
Cubic yards excavated 242
Total distance moved forward during day . . . . . . 78′
Number of times moved forward 12
Average distance moved forward in one move . . . . 6′ 6″
Average time between beginning of one shovel move and beginning of next, 46.1 minutes.
Number of cars to one shovel move 10.1
Time shovel is interrupted while spotting one car . .083 minute
Minutes per working day less time for accidental delays . 604
Area of section . . 200 square feet when material was blasted
Height of face . . 7 ½ square feet when material was blasted
Number of times blasted bank 3
Coal used . . . . 2.28 tons

TIME STUDY—FIRST DAY

	Forenoon	Afternoon
Started work	6:59	1:03
Stopped work	12:04	6:06

	Min.		Min.		Min.		
Total time worked	305	+	303	=	608	=	10 hours 8 minutes.

	Minutes	Seconds	Per Cent
Actual working	274	00	45.1
Spotting cars	10	00	1.6
Waiting for cars	5	30	0.9
Moving shovel	180	00	29.6
Idle			
Blasting	61	00	10.0
Boulder in bucket	9	30	1.6
Repairing dinkey track . . .	15	30	2.6
Miscellaneous delays			
Clearing track	35	30	5.8
Moving boulders	12	00	2.0
Tearing down bank	2	00	0.3
Car off track	3	00	0.5
Total time under observation .	608	00	100 0

Cost of Direct Labor (Loading) per Day	Standard Basis
Runner	$5.00
Craneman	3.60
Fireman	2.40
6 pitmen	9.00
1 coalman	1.50
	$21.50

Number of cubic yards loaded on day of observation . . 242

Cost of direct labor per day per cubic yard $\frac{\$21.50}{242} = 8.88$ cents per cubic yard.

Process Analysis	Time		Per Cent	Cost per Yard in Cents	Total Cost in Cents
	Min.	Sec.			
Charge to waiting for blasters	75	00	12.3	1.092	1.092
Charge to loading					
1. Actual loading	274	00	45.1	4.004	6.776
2. Delays					
a Moving up	180	00	29.6	2.630	
b Miscellaneous	9	30	1.6	0.142	
Charge to transporting and dumping					
1. Waiting for trains	15	30	2.5	0.222	1.012
2. Miscellaneous	54	00	8.9	0 790	
	608	00	100.0	. . .	8.88

Dipper Performance		Minimum	Average	Maximum	No. of Observations	No. of Attempts
Digging	Time in seconds	3	12.3	30.5	21	48
Swinging loaded		3	5.3	9	21	
Swinging empty		4	5.3	11		
Falling		2	3.5	6		
Total time to fill and load one dipperful		12	26.4	56 5	..	..

Time for one complete swing

	Minimum	Average	Maximum	Number of Observations
Seconds	14	18.1	28	21

OBSERVATIONS—SECOND DAY

Number of cars loaded 84
Cubic yards excavated 168
Total distance moved forward during day . . . . . . 28′
Number of times moved forward 8
Maximum distance moved forward in one move . . . . 6′ 2″
Average time between beginning of one shovel move and beginning of next, 43.9 minutes
Number of cars to one shovel move 11.2
Time shovel is interrupted to change train . . . 18 minutes
Area of section . . . . 225 square feet
Height of face . . . . 9′
Number of times blasted bank 4

TIME STUDY

	Forenoon	Afternoon
Started work	7:00	1:06
Stopped work	12:08	6:04

Min. Min.
Total time worked 308 + 298 = 606 minutes = 10 hours 6 minutes

	Minutes	Seconds	Per Cent
Actual working	151	15	25.0
Spotting cars	7	30	1.2
Waiting for cars	18	. .	3.0
Moving shovel	89	45	14.8
Idle			
Blasting	309	. .	51.0
Miscellaneous delays . . .	(30	30)	(5.0)
Pulling in bank	26	30	4 4
Moving boulders	4	. .	0.6
Total time under observation .	606	00	100.0

Cost of direct labor per day, loading $21.50
Cubic yards loaded on second day of observation . . . 168

Cost of direct labor per day per cubic yard $\frac{\$21.50}{168} = $ 12.80 cents per yard

Process Analysis	Time Min.	Time Sec.	Per Cent	Cost Per Yard in Cents	Total Cost
Charge to loosening or breaking . . .	339	30	56.0	7.167	7.167
Charge to loading					
1. Actual loading .	151	15	25.0	3.200	5.095
2. Delays					
a Moving up . .	89	45	14.8	1.895	
Charge to transporting and dumping					
1 Waiting for trains	25	30	4.2	0.538	0.538
	606	00	100 0		12.80

Dipper Performance		Minimum	Average	Maximum	Number Observations	Number Attempts
Digging	Time in seconds	4.0	9.3	30	51	51
Swinging loaded .	Time in seconds	3.0	4.4	6¾	51	
Swinging empty .	Time in seconds	3.0	4.3	6½	51	
Falling empty . .	Time in seconds	2.0	5.2	16¾	51	
Time to fill and load one dipperful		12.0	23.2	60	51	

Time for one complete swing

	Minimum	Average	Maximum	Number Observations
Seconds . . .	12.0	15.3	19.5	51

TRANSPORTATION (See Report No. 795)

Moving Shovel	Average Seconds	Number of Observations
Unjacking	131	2
Leveling in front	49	1
Laying ties	77	4
Laying rails	69	5
Unclamping	25	1
Moving	21	4
Clamping up	66	3
Jacking up	167	2
Carrying rails to front	40	3
Carrying ties to front	49	3
	694 = 11 minutes 34 seconds	

Cost of Labor to Move No. 875 From Siding to Work		Standard Basis
Runner	80 hours @ $0.50 =	$40 00
Craneman	80 hours @ 0.36 =	28.80
Fireman	80 hours @ 0.24 =	19.20
Watchman	80 hours @ 0.15 =	12.00
Foreman	80 hours @ 0.20 =	16.00
Laborers	1135 hours @ 0.15 =	170.25
Team, ties	130 hours @ 0.30 =	39.00
Team, coal	50 hours @ 0.30 =	15.00
Coal		28.00
Oil		8.50
		$376.75

Fig. 86

Fig. 87. Bucyrus Shovel No. 875 on D., L. & W. Cut-off

CHAPTER X

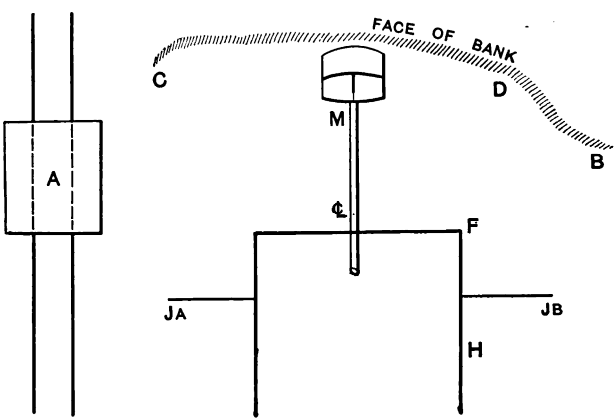
DIRECTIONS FOR MOVING SHOVEL

ECONOMIC HINTS In order to systematize the various operations in moving a steam shovel and thus reduce the cost to a minimum, as referred to in Chapter II, we have given the order in which these movements should be made.

A contractor who finds, upon timing his work, that he is not moving his shovels within the limit given in this chapter, will do well to investigate wherein his trouble lies by comparing the actions of his men with the movements herein tabulated.

We also give in this chapter valuable hints to superintendents and managers, which, if adhered to, will be of great assistance in obtaining economical results.

For the use of estimators we have given, in Chapter IV, a complete classification of the items to be considered, and in this chapter a few important hints which we believe will also be of assistance.



(1) Just before moving, the last dipperful will be taken from B. As this dipper is being filled, runner gives one whistle signal to the pit gang (six men in pit). Two men go to JA and two to JB, and one man goes out to F on the rail clamp and one to H on the rail clamp.

(2) As soon as the dipper has swung to the left of the center (M) JB is loose, and one of the men there runs up the screw.

(3) One man at JA puts his pole over the jack and gets ready to raise his jack block. Meanwhile the dipper has dumped at A.

(4) Other man at JB now raises his jack block and is ready to move.

(5) Dipper swings to the right far enough past M to take the weight off of JA, which is immediately screwed up and the block raised.

(6) While runner is throwing in his moving clutch, one man at F is knocking loose rail clamp, and one man from JA and one from JB pick up the chock and carry it forward to its new position.

(7) Runner now moves shovel ahead; H knocks the clamp loose. F is meanwhile putting his clamp on in the new position.

(8) As soon as the shovel strikes the front chock, H puts his clamp on. The bucket is in the center position for this movement.

(9) The jackmen JA and JB immediately screw down their jacks, and the first man to get his jack down gives signal to runner, who takes first bucketful on his side. This enables man on either side to get his jack well screwed down before bucket crosses center line again, working away at full speed.

Shovel now works away even if a little out of level. It can be leveled up by runner telling JA or JB to loosen a little, the opposite man screwing down on the next half swing.

HINTS

(1) Drag rear chock by chains fastened to the shovel.

(2) Have jackmen use jack arm for fulcrum on which to rest poles for carrying jack block.

ECONOMIC HINTS TO SUPERINTENDENTS

Cultivate the habit of learning new methods from published accounts, and then don't wait to see them used, but apply them yourself, even if you have to devise some details which were not described. The man

who avails himself of published data becomes a centenarian in experience before he is thirty in years.

Responsibility without authority, and authority without responsibility, are fatal to successful work. Don't let the men "knock" each other on the work.

One of the secrets of successful management consists in quickly finding out who is inefficient. The best superintendent always hails "from Missouri."

One of Gilbreth's rules: No superintendent, walking-boss, engineer, time-keeper, or other employee is permitted to give an order direct to any workman, except in case of great emergency. Not even a member of the firm is exempt from this rule. The foreman in direct charge of a gang is the only man permitted to instruct his men what to do. He is the officer in charge, and his superior officers must not, intentionally or unintentionally, degrade him in the eyes of his men by issuing orders over his head.

In order to get the most work out of a man for his money it is necessary to offer him a stronger incentive to do his best than the mere fear of discharge for incompetency.

It is highly economical to use all possible means to prevent men from getting injured on the work.

Don't mistake activity for work.

Look out for the man whose mind is centered upon more help instead of more method.

One of the most demoralizing agents on a large piece of construction work is the rumor, especially if the rumor is true, that the work is being unsuccessfully prosecuted. The belief that the contractor is losing money, if allowed to circulate among his own men is almost fatal to a high state of discipline and efficiency.

Time-keeper must not gossip on the work, a sure cause of dissatisfaction. The men should know as little of the politics of the work as possible. Dissentions at headquarters are bound to affect the men and

their work. If unity is lacking in high places it will also be lacking lower down.

Don't let the executive do any avoidable detail work

It may be economical to pay higher wages than the prevailing rate. This attracts the best class of labor. Men will often do 10 per cent more work for 5 per cent more pay.

Cut of 10 per cent in wages may mean reduction of 20 per cent in output.

Differential rates of pay for the same kind of work are a menace to effective results.

To avoid demoralization men must be paid promptly on regular pay day. No matter how sure the men may be of their pay, failure to meet them on pay day affects the work badly.

Rule of Gilbreth's: No smoking allowed on the job except to finish noon smoke. Not over one-half hour and no refilling of pipes.

Gilbreth advertises that he will pay one dollar for every suggestion that is made by an employee and accepted by the company, and they award monthly the sum of $20 for the most valuable suggestion received during the previous month. First prize $10, second prize $5, third prize $3, and fourth prize $2. As soon as awards are made prizes are paid in cash. A notice is posted to this effect on every job.

All monthly men or steady pay men should be on the job before the first whistle is sounded and remain there until quitting time regardless of weather.

A daily report should be sent to the home office on the blanks provided. If no work is being done, still a report should be sent in stating that fact, and giving reasons for delays, etc.

All sources of dissatisfaction should be immediately and impartially investigated, and the men must know that, although they are responsible for the quantity of their work to the immediate foreman, they are abso-

lutely in touch with the management as far as justice to the men is concerned.

Poor coal supply causes serious delay and loss of money.

Breakdowns of machinery will cause loss of money which cannot be estimated and will always be uneconomical.

Keep parts of all machines together in storage, so that they can be easily found.

Upon laying up rock drills, hoists, etc., cover the bright surface with a mixture of paraffin and vaseline heated and applied with a brush. The mixture is readily rubbed off.

In cold weather, at night, drain all water and oil from cylinders and lubricators of engines and pumps. The common lard oils are full of acid and will cut machinery.

By means of lye bath and air blasts, dirty, greasy machinery may be quickly cleaned.

Cylinders of engines and steam drills are frequently cracked in cold weather by suddenly letting in steam. To avoid this, open drip cocks and cocks on steam chest and blow in steam for a few minutes to warm up the cylinder before starting the machine. A broken cylinder may delay work for a week or longer.

Test boiler gauges from time to time.

Use three-wire connection with three-wire machine for blasting.

Look out for air in water pipe at top of a grade. Provide a blow-off cock.

Description of the work on the Sonlengs Canal states that clay excavated by steam shovels came out in lumps so hard that it could not be cut up economically. The problem was solved by the use of a sprinkling hose.

A 16-foot hickory or ash pole, shod with a pointed spike for breaking down the bank in front of the shovel in deep cuts is often a great time saver.

Steam shovels can be buried by slips where the bank is too high.

When the shovel has a lift of 9 feet, and it is desired to take out a 12-foot cut, this can often be done by putting the shovel on stilts, as it were, i. e., blocking up the tracks the requisite amount.

Plot the location of all drill holes on cross-section paper and write thereon the depth of each hole and the powder charge in it.

In drilling open cut work it is wise to pitch the holes down away from the face. The explosion will then throw the rock away from the face.

In forging rock-drill bits, those for medium hard rock should have sharp chisel bits. As the hardness of the rock increases, the angle of the bit may be made more obtuse and the cutting edge shaped from a straight line to a curve to prevent the corners from being chipped off.

There should be no air cushions in the blast hole. To accomplish this, slit the cartridges with a knife lengthwise of two sides, being sure not to do this to a frozen or partly frozen stick, and place it well home with a wooden rammer.

In springing for black powder work, it is important not to load the hole until after the rock has cooled off, as the springing charge develops considerable heat.

The usual size of a case of dynamite is three-quarters of a cubic foot, therefore an old powder box is often much more convenient for measuring coal than a bushel basket.

Dynamite, when frozen, can sometimes be exploded by extra strong caps.

Don't blow unexploded dynamite out of a hole with a steam jet. Use air instead.

ADVANTAGE OF WHISTLE OR BELL SIGNALS OVER HAND SIGNALS

To get hand signals, a man must look for the signals, which requires that he should be constantly watching the signal man and will be unable to give his attention to other things. Bell or whistle signals do not require his attention.

Acknowledgment should be made of the excellent field work in gathering the data contained in this volume by Messrs. F. M. GAIGER, CHAS. HOUSTON, E. C. WILDER, A. C. HASKELL and W. T. BALL, and the marked courtesy rendered us by all the contractors to whom we applied for information.

No effort has been spared to make this book entirely trustworthy as to facts, but although it has been carefully checked for errors it is possible that mistakes may have escaped notice. If any should be noted by the reader a memorandum to that effect addressed to the Construction Service Co., 15 William Street, New York City, would be much appreciated.

R. T. DANA

For Construction Service Company

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CHAPTER IV—*Continued*

CHAPTER VII—*Continued*